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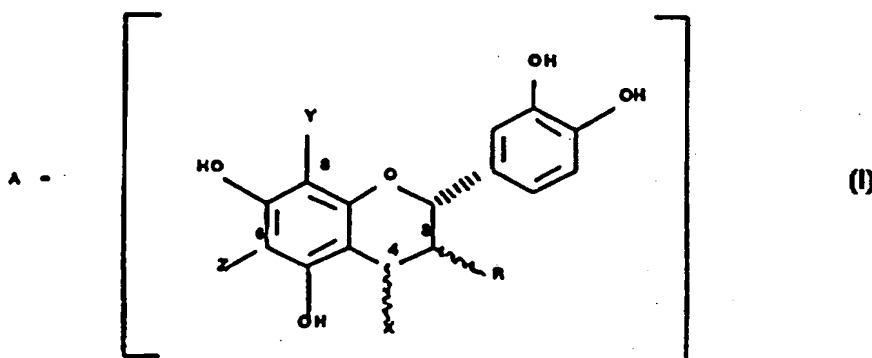




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(54) Title: COCOA EXTRACT COMPOUNDS AND METHODS FOR MAKING AND USING THE SAME



## (57) Abstract

Disclosed and claimed are cocoa extracts such as polyphenols or procyanidins, methods for preparing such extracts, as well as uses for them, especially a compound of formula (I), wherein:  $n$  is an integer from 3 to 12, such that there is a first monomeric unit A, and a plurality of other monomeric units; R is 3-( $\alpha$ )-OH, 3-( $\beta$ )-OH, 3-( $\alpha$ )-O-sugar, or 3-( $\beta$ )-O-sugar; position 4 is alpha or beta stereochemistry; X, Y and Z represent positions for bonding between monomeric units, with the provisos that as to the first monomeric unit, bonding of another monomeric unit thereto is at position 4 and Y = Z = hydrogen, and, that when not for bonding monomeric units, X, Y and Z are hydrogen or alpha or beta sugar; and the sugar can be optionally substituted with a phenolic moiety via an ester bond.

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**COCOA EXTRACT COMPOUNDS AND METHODS  
FOR MAKING AND USING THE SAME**

**REFERENCE TO RELATED APPLICATION**

5           Reference is made to copending U.S. application  
Serial No. 08/317,226, filed October 3, 1994, incorporated  
herein by reference.

**FIELD OF THE INVENTION**

10           This invention relates to cocoa extracts and  
compounds therefrom such as polyphenols preferably  
polyphenols enriched with procyanidins. This invention also  
relates to methods for preparing such extracts and  
compounds, as well as to uses for them; for instance, as  
antineoplastic agents, antioxidants, DNA topoisomerase II  
15   enzyme inhibitors, cyclo-oxygenase and/or lipoxxygenase  
modulators, NO (Nitric Oxide) or NO-synthase modulators,  
blood or in vivo glucose modulators, and antimicrobials.

          Documents are cited in this disclosure with a full  
citation for each appearing thereat or in a References  
20   section at the end of the specification, preceding the  
claims. These documents pertain to the field of this  
invention; and, each document cited herein is hereby  
incorporated herein by reference.

**BACKGROUND OF THE INVENTION**

25           Polyphenols are an incredibly diverse group of  
compounds (Ferreira et al., 1992) which widely occur in a  
variety of plants, some of which enter into the food chain.  
In some cases they represent an important class of compounds  
for the human diet. Although some of the polyphenols are  
30   considered to be nonnutrative, interest in these compounds  
has arisen because of their possible beneficial effects on  
health. For instance, quercetin (a flavonoid) has been  
shown to possess anticarcinogenic activity in experimental

animal studies (Deshner et al., 1991 and Kato et al., 1983).  
(+)-Catechin and (-)-epicatechin (flavan-3-ols) have been  
shown to inhibit Leukemia virus reverse transcriptase  
activity (Chu et al., 1992). Nobotanin (an oligomeric  
5 hydrolyzable tannin) has also been shown to possess anti-  
tumor activity (Okuda et al., 1992). Statistical reports  
have also shown that stomach cancer mortality is  
significantly lower in the tea producing districts of Japan.  
Epigallocatechin gallate has been reported to be the  
10 pharmacologically active material in green tea that inhibits  
mouse skin tumors (Okuda et al., 1992). Ellagic acid has  
also been shown to possess anticarcinogen activity in  
various animal tumor models (Bukharta et al., 1992).  
Lastly, proanthocyanidin oligomers have been patented by the  
15 Kikkoman Corporation for use as antimutagens. Indeed, the  
area of phenolic compounds in foods and their modulation of  
tumor development in experimental animal models has been  
recently presented at the 202nd National Meeting of The  
American Chemical Society (Ho et al., 1992; Huang et al.,  
20 1992).

However, none of these reports teaches or suggests  
cocoa extracts or compounds therefrom, any methods for  
preparing such extracts or compounds therefrom, or, any uses  
for cocoa extracts or compounds therefrom, as antineoplastic  
25 agents, anti-oxidants, anti-microbials, cyclo-oxygenase  
and/or lipoxxygenase modulators, NO or NO-synthase  
modulators, and blood or in vivo glucose modulators.

#### OBJECTS AND SUMMARY OF THE INVENTION

Since unfermented cocoa beans contain substantial  
30 levels of polyphenols, the present inventors considered it  
possible that similar activities of and uses for cocoa  
extracts, e.g., compounds within cocoa, could be revealed by

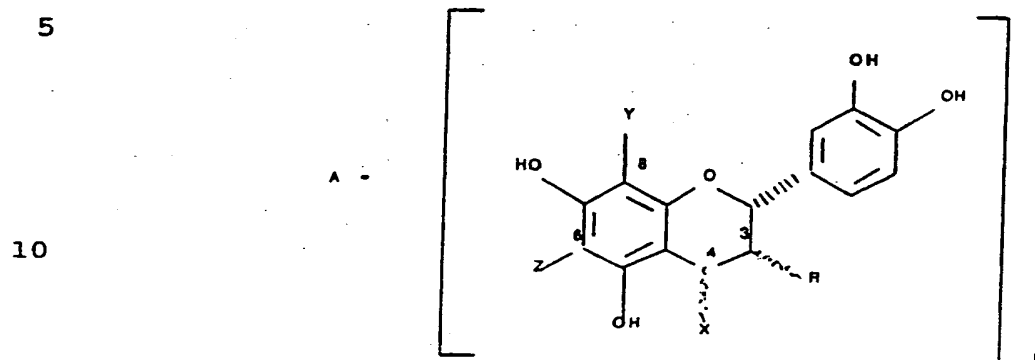
extracting such compounds from cocoa and screening the extracts for activity. The National Cancer Institute has screened various *Theobroma* and *Herrania* species for anti-cancer activity as part of their massive natural product selection program. Low levels of activity were reported in some extracts of cocoa tissues, and the work was not pursued. Thus, in the antineoplastic or anti-cancer art, cocoa and its extracts were not deemed to be useful; i.e., the teachings in the antineoplastic or anti-cancer art lead the skilled artisan away from employing cocoa and its extracts as cancer therapy.

Since a number of analytical procedures were developed to study the contributions of cocoa polyphenols to flavor development (Clapperton et al., 1992), the present inventors decided to apply analogous methods to prepare samples for anti-cancer screening, contrary to the knowledge in the antineoplastic or anti-cancer art. Surprisingly, and contrary to the knowledge in the art, e.g., the National Cancer Institute screening, the present inventors discovered that cocoa polyphenol extracts which contain procyanidins, have significant utility as anti-cancer or antineoplastic agents. Additionally, the inventors demonstrate that cocoa extracts containing procyanidins and compounds from cocoa extracts have utility as antioxidants, antineoplastics, antimicrobials, cyclo-oxygenase and/or lipxygenase modulators, NO or NO-synthase modulators, and blood or in vivo glucose modulators.

It is an object of the present invention to provide a method for producing cocoa extract and/or compounds therefrom.

It is another object of the invention to provide a cocoa extract and/or compounds therefrom.

It is still another object of the present invention to provide compounds of the formula and methods for obtaining a compound of the formula:



wherein:

15  $n$  is an integer from 3 to 12, such that there is a first monomeric unit A, and a plurality of other monomeric units;

$R$  is 3-( $\alpha$ )-OH, 3-( $\beta$ )-OH, 3-( $\alpha$ )-O-sugar, or 3-( $\beta$ )-O-sugar;

20 position 4 is alpha or beta stereochemistry;

$X$ ,  $Y$  and  $Z$  represent positions for bonding between monomeric units, with the provisos that as to the first monomeric unit, bonding of another monomeric unit thereto is at position 4 and  $Y = Z = \text{hydrogen}$ , and, that when not for bonding monomeric units  $X$ ,  $Y$  and  $Z$  are hydrogen, or  $Z$ ,  $Y$  are sugar and  $X$  is hydrogen, or  $X$  is alpha or beta sugar and  $Z$ ,  $Y$  are hydrogen, or combinations thereof. The compound can have  $n$  as 5 to 12, and certain preferred compounds have  $n$  as 5. The sugar can be selected from the group consisting essentially of glucose, galactose, xylose, rhamnose, and arabinose. The sugar of any or all of  $R$ ,  $X$ ,  $Y$  and  $Z$  can

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optionally be substituted with a phenolic moiety via an ester bond.

It is another object of the invention to provide an antioxidant composition.

5 It is another object of the invention to demonstrate inhibition of DNA topoisomerase II enzyme activity.

It is yet another object of the present invention to provide a method for treating tumors or cancer.

10 It is still another object of the invention to provide an anti-cancer, anti-tumor or antineoplastic composition.

It is still a further object of the invention to provide an antimicrobial composition.

15 It is yet another object of the invention to provide a cyclo-oxygenase and/or lipxygenase modulating composition.

It is still another object of the invention to provide an NO or NO-synthase-modulating composition.

20 It is another object of the invention to provide a blood or in vivo glucose-modulating composition.

It is yet a further object of the invention to provide a method for treating a patient with an antineoplastic, antioxidant, antimicrobial, cyclo-oxygenase and/or lipxygenase modulating or NO or  
25 NO-synthase modulating and/or blood or in vivo glucose-modulating composition.

It is a further object of the invention to provide a method for making any of the aforementioned compositions.

30 And, it is an object of the invention to provide a kit for use in the aforementioned methods or for preparing the aforementioned compositions.

It has been surprisingly discovered that cocoa extract, and compounds therefrom, have anti-tumor, anti-cancer or antineoplastic activity or, is an antioxidant composition or, inhibits DNA topoisomerase II enzyme activity or, is an antimicrobial or, is a cyclo-oxygenase and/or lipoxxygenase modulator or, is a NO or NO-synthase modulator or, is a blood or *in vivo* glucose modulator.

Accordingly, the present invention provides a substantially pure cocoa extract and compounds therefrom. The extract or compounds preferably comprises polyphenol(s) such as polyphenol(s) enriched with cocoa procyanidin(s), such as polyphenols of at least one cocoa procyanidin selected from (-) epicatechin, (+) catechin, procyanidin B-2, procyanidin oligomers 2 through 12, preferably 2 through 5 or 4 through 12, more preferably 3 through 12, and most preferably 5 through 12, procyanidin B-5, procyanidin A-2 and procyanidin C-1.

The present invention also provides an anti-tumor, anti-cancer or antineoplastic or antioxidant or DNA topoisomerase II inhibitor, or antimicrobial, or cyclo-oxygenase and/or lipoxxygenase modulator, or an NO or NO-synthase modulator, or blood or *in vivo* glucose modulator composition comprising a substantially pure cocoa extract or compound therefrom or synthetic cocoa polyphenol(s) such as polyphenol(s) enriched with procyanidin(s) and a suitable carrier, e.g., a pharmaceutically, veterinary or food science acceptable carrier. The extract or compound therefrom preferably comprises cocoa procyanidin(s). The cocoa extract or compounds therefrom is preferably obtained by a process comprising reducing cocoa beans to powder, defatting the powder and, extracting and purifying active compound(s) from the powder.

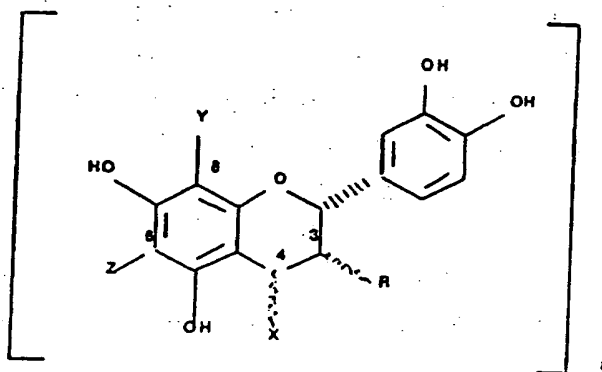
The present invention further comprehends a method for treating a patient in need of treatment with an anti-tumor, anti-cancer, or antineoplastic agent or an antioxidant, or a DNA topoisomerase II inhibitor, or antimicrobial, or cyclo-oxygenase and/or lipoxxygenase modulator, or an NO or NO-synthase modulator, or blood or *in vivo* glucose modulator comprising administering to the patient a composition comprising an effective quantity of a substantially pure cocoa extract or compound therefrom or synthetic cocoa polyphenol(s) or procyanidin(s) and a carrier, e.g., a pharmaceutically, veterinary or food science acceptable carrier. The cocoa extract or compound therefrom can be cocoa procyanidin(s); and, is preferably obtained by reducing cocoa beans to powder, defatting the powder and, extracting and purifying active compound(s) from the powder.

Additionally, the present invention provides a kit for treating a patient in need of treatment with an anti-tumor, anti-cancer, or antineoplastic agent or antioxidant or DNA topoisomerase II inhibitor, or antimicrobial, or cyclo-oxygenase and/or lipoxxygenase modulator, or an NO or NO-synthase modulator, or blood or *in vivo* glucose modulator comprising a substantially pure cocoa extract or compounds therefrom or synthetic cocoa polyphenol(s) or procyanidin(s) and a suitable carrier, e.g., a pharmaceutically, veterinary or food science acceptable carrier, for admixture with the extract or compound therefrom or synthetic polyphenol(s) or procyanidin(s).

Further, the present invention provides a compound of the formula:

5

A -



10 wherein:

$n$  is an integer from 3 to 12, such that there is a first monomeric unit A, and a plurality of other monomeric units;

15 R is 3-( $\alpha$ )-OH, 3-( $\beta$ )-OH, 3-( $\alpha$ )-O-sugar, or 3-( $\beta$ )-O-sugar;

position 4 is alpha or beta stereochemistry;

20 X, Y and Z represent positions for bonding between monomeric units, with the provisos that as to the first monomeric unit, bonding of another monomeric unit thereto is at position 4 and  $Y = Z = \text{hydrogen}$ , and, that when not for bonding monomeric units, X, Y and Z are hydrogen, or Z, Y are supra and X is hydrogen, or X is alpha or beta sugar and Z, Y are hydrogen, or combinations thereof. The compound can have  $n$  as 5 to 12, and certain preferred compounds have

25  $n$  as 5. The sugar can be selected from the group consisting essentially of glucose, galactose, xylose, rhamnose, and arabinose. The sugar of any or all of R, X, Y and Z can optionally be substituted with a phenolic moiety via an ester bond. Preferred compounds are illustrated in Figs.

30 38A to 38P and 39A to 39AA. Linkages of 4-6 and 4-8 are presently preferred.

The present invention in another embodiment provides an antineoplastic composition comprising an inventive compound and a pharmaceutically, veterinary or food science acceptable carrier.

5 In a further embodiment the invention provides an antimicrobial composition comprising an inventive compound and a suitable carrier or diluent.

The invention also provides a cyclo-oxygenase and/or lipoxxygenase modulator composition comprising an  
10 inventive compound and a suitable carrier or diluent.

The invention additionally provides a NO or NO-synthase-modulating composition comprising an inventive compound and a suitable carrier or diluent.

The invention comprehends a blood or *in vivo*  
15 glucose-modulating composition comprising an inventive compound and a suitable carrier or diluent.

Still further, the invention comprehends a method for treating a patient in need of treatment with an antineoplastic agent, or antioxidant agent/composition, or a  
20 DNA topoisomerase II inhibitor or composition, or antimicrobial agent/composition, or cyclo-oxygenase and/or lipoxxygenase modulating agent/composition, or NO or NO-synthase modulating agent/composition, or blood or *in vivo* glucose-modulating agent/composition comprising  
25 administering to the patient a composition comprising an effective quantity of an inventive compound and a suitable carrier.

The invention even further encompasses food preservation or preparation compositions comprising an  
30 inventive compound, and methods for preparing or preserving food by adding the composition to food.

And, the invention still further encompasses a DNA topoisomerase II inhibitor comprising an inventive compound and a suitable carrier or diluent, and methods for treating a patient in need of such treatment by administration of the composition.

Considering broadly the aforementioned embodiments involving cocoa extracts, the invention also includes such embodiments wherein an inventive compound is used instead of or as the cocoa extracts. Thus, the invention comprehends kits, methods, and compositions analogous to those above-stated with regard to cocoa extracts and with an inventive compound.

These and other objects and embodiments are disclosed or will be obvious from the following Detailed Description.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The following Detailed Description will be better understood by reference to the accompanying drawings wherein:

Fig. 1 shows a representative gel permeation chromatogram from the fractionation of crude cocoa procyanidins;

Fig. 2A shows a representative reverse-phase HPLC chromatogram showing the separation (elution profile) of cocoa procyanidins extracted from unfermented cocoa;

Fig. 2B shows a representative normal phase HPLC separation of cocoa procyanidins extracted from unfermented cocoa;

Fig. 3 shows several representative procyanidin structures;

Figs. 4A-4E show representative HPLC chromatograms of five fractions employed in screening for anti-cancer or antineoplastic activity;

5 Figs. 5 and 6A-6D show the dose-response relationship between cocoa extracts and cancer cells ACHN (Fig. 5) and PC-3 (Figs. 6A-6D) (fractional survival vs. dose,  $\mu\text{g/mL}$ ); M&M2 F4/92, M&MA+E U12P1, M&MB+E Y192P1, M&MC+E U12P2, M&MD+E U12P2;

10 Figs. 7A to 7H show the typical dose response relationships between cocoa procyanidin fractions A, B, C, D, E, A+B, A+E, and A+D, and the PC-3 cell line (fractional survival vs. dose,  $\mu\text{g/mL}$ ); MM-1A 0212P3, MM-1 B 0162P1, MM-1 C 0122P3, MM-1 D 0122P3, MM-1 E 0292P8, MM-1 A/B 0292P6, MM-1 A/E 0292P6, MM-1 A/D 0292P6;

15 Figs. 8A to 8H show the typical dose response relationships between cocoa procyanidin fractions A, B, C, D, E, A+B, B+E, and D+E and the KB Nasopharyngeal/HeLa cell line (fractional survival vs. dose,  $\mu\text{g/mL}$ ); MM-1A092K3, MM-1 B 0212K5, MM-1 C 0162K3, MM-1 D 0212K5, MM-1 E 0292K5, MM-1 A/B 0292K3, MM-1 B/E 0292K4, MM-1 D/E 0292K5;

20 Figs. 9A to 9H show the typical dose response relationship between cocoa procyanidin fractions A, B, C, D, E, B+D, A+E and D+E and the HCT-116 cell line (fractional survival vs. dose,  $\mu\text{g/mL}$ ); MM-1 C 0192H5, D 0192H5, E 0192H5, MM-1 B&D 0262H2, A/E 0262H3, MM-1 D&E 0262H1;

25 Figs. 10A to 10H show typical dose response relationships between cocoa procyanidin fractions A, B, C, D, E, B+D, C+D and A+E and the ACHN renal cell line (fractional survival vs. dose,  $\mu\text{g/mL}$ ); MM-1 A 092A5, MM-1 B 092A5, MM-1 C 0192A7, MM-1 D 0192A7, M&M1 E 0192A7, MM-1 B&D 0302A6, MM-1 C&D 0302A6, MM-1 A&E 0262A6;

Figs. 11A to 11H show typical dose response relationships between cocoa procyanidin fractions A, B, C, D, E, A+E, B+E and C+E and the A-549 lung cell line (fractional survival vs. dose,  $\mu\text{g/mL}$ ); MM-1 A 019258, MM-1 B 09256, MM-1 C 019259, MM-1 D 019258, MM-1 E 019258, A/E 026254, MM-1 B&E 030255, MM-1 C&E N6255;

Figs. 12A to 12H show typical dose response relationships between cocoa procyanidin fractions A, B, C, D, E, B+C, C+D and D+E and the SK-5 melanoma cell line (fractional survival vs. dose  $\mu\text{g/mL}$ ); MM-1 A 0212S4, MM-1 B 0212S4, MM-1 C 0212S4, MM-1 D 0212S4, MM-1 E N32S1, MM-1 B&C N32S2, MM-1 C&D N32S3, MM-1 D&E N32S3;

Figs. 13A to 13H show typical dose response relationships between cocoa procyanidin fractions A, B, C, D, E, B+C, C+E, and D+E and the MCF-7 breast cell line (fractional survival vs. dose,  $\mu\text{g/mL}$ ); MM-1 A N22M4, MM-1 B N22M4, MM-1 C N22M4, MM-1 D N22M3, MM-1 E 0302M2, MM-1 B/C 0302M4, MM-1 C&E N22M3, MM-1 D&E N22M3;

Fig. 14 shows typical dose response relationships for cocoa procyanidin (particularly fraction D) and the CCRF-CEM T-cell leukemia cell line (cells/mL vs. days of growth; open circle is control, darkened circle is  $125\mu\text{g}$  fraction D, open inverted triangle is  $250\mu\text{g}$  fraction D, darkened inverted triangle is  $500\mu\text{g}$  fraction D);

Fig. 15A shows a comparison of the XTT and Crystal Violet cytotoxicity assays against MCF-7 p168 breast cancer cells treated with fraction D+E (open circle is XTT and darkened circle is Crystal Violet);

Fig. 15B shows a typical dose response curve obtained from MDA MB231 breast cell line treated with varying levels of crude polyphenols obtained from UIT-1 cocoa genotype (absorbance (540nm) vs. Days; open circle is



control, darkened circle is vehicle, open inverted triangle is 250 $\mu$ g/mL, darkened inverted triangle is 100 $\mu$ g/mL, open square is 10 $\mu$ g/mL; absorbance of 2.0 is maximum of plate reader and may not be necessarily representative of cell number);

Fig. 15C shows a typical dose response curve obtained from PC-3 prostate cancer cell line treated with varying levels of crude polyphenols obtained from UIT-1 cocoa genotype (absorbance (540nm) vs. Days; open circle is control, darkened circle is vehicle, open inverted triangle is 250 $\mu$ g/mL, darkened inverted triangle is 100 $\mu$ g/mL and open square is 10 $\mu$ g/mL);

Fig. 15D shows a typical dose-response curve obtained from MCF-7 p168 breast cancer cell line treated with varying levels of crude polyphenols obtained from UIT-1 cocoa genotype (absorbance (540nm) vs. Days; open circle is control, darkened circle is vehicle, open inverted triangle is 250 $\mu$ g/mL, darkened inverted triangle is 100 $\mu$ g/mL, open square is 10 $\mu$ g/mL, darkened square is 1 $\mu$ g/mL; absorbance of 2.0 is maximum of plate reader and may not be necessarily representative of cell number);

Fig. 15E shows a typical dose response curve obtained from Hela cervical cancer cell line treated with varying levels of crude polyphenols obtained from UIT-1 cocoa genotype (absorbance (540nm) vs. Days; open circle is control, darkened circle is vehicle, open inverted triangle is 250 $\mu$ g/mL, darkened inverted triangle is 100 $\mu$ g/mL, open square is 10 $\mu$ g/mL; absorbance of 2.0 is maximum of plate reader and may not be necessarily representative of cell number);

Fig. 15F shows cytotoxic effects against Hela cervical cancer cell line treated with different cocoa

polyphenol fractions (absorbance (540nm) vs. Days; open circle is 100 $\mu$ g/mL fractions A-E, darkened circle is 100 $\mu$ g/mL fractions A-C, open inverted triangle is 100 $\mu$ g/mL fractions D&E; absorbance of 2.0 is maximum of plate reader and not representative of cell number);

Fig. 15G shows cytotoxic effects at 100ul/mL against SKBR-3 breast cancer cell line treated with different cocoa polyphenol fractions (absorbance (540nm) vs. Days; open circle is fractions A-E, darkened circle is fractions A-C, open inverted triangle is fractions D&E);

Fig. 15H shows typical dose-response relationships between cocoa procyanidin fraction D+E on Hela cells (absorbance (540nm) vs. Days; open circle is control, darkened circle is 100 $\mu$ g/mL, open inverted triangle is 75 $\mu$ g/mL, darkened inverted triangle is 50 $\mu$ g/mL, open square is 25 $\mu$ g/mL, darkened square is 10 $\mu$ g/mL; absorbance of 2.0 is maximum of plate reader and is not representative of cell number);

Fig. 15I shows typical dose-response relationship between cocoa procyanidin fraction D+E on SKBR-3 cells (absorbance (540nm) vs. Days; open circle is control, darkened circle is 100 $\mu$ g/mL, open inverted triangle is 75 $\mu$ g/mL, darkened inverted triangle is 50 $\mu$ g/mL, open square is 25 $\mu$ g/mL, darkened square is 10 $\mu$ g/mL);

Fig. 15J shows typical dose-response relationships between cocoa procyanidin fraction D+E on Hela cells using the Soft Agar Cloning assay (bar chart; number of colonies vs. control, 1, 10, 50, and 100 $\mu$ g/mL);

Fig. 15K shows the growth inhibition of Hela cells when treated with crude polyphenol extracts obtained from

eight different cocoa genotypes (% control vs. concentration,  $\mu\text{g/mL}$ ; open circle is C-1, darkened circle is C-2, open inverted triangle is C-3, darkened inverted triangle is C-4, open square is C-5, darkened square is C-6, open triangle is C-7, darkened triangle is C-8; C-1 = UF-12: horti race = Trinitario and description is crude extracts of UF-12 (Brazil) cocoa polyphenols (decaffeinated/detheobrominated); C-2 = NA-33: horti race = Forastero and description is crude extracts of NA-33 (Brazil) cocoa polyphenols (decaffeinated/detheobrominated); C-3 = EEG-48: horti race = Forastero and description is crude extracts of EEG-48 (Brazil) cocoa polyphenols (decaffeinated/detheobrominated); C-4 = unknown: horti race = Forastero and description is crude extracts of unknown (W. African) cocoa polyphenols (decaffeinated/detheobrominated); C-5 = UF-613: horti race = Trinitario and description is crude extracts of UF-613 (Brazil) cocoa polyphenols (decaffeinated/detheobrominated); C-6 = ICS-100: horti race = Trinitario (to Nicaraguan Criollo ancestor) and description is crude extracts of ICS-100 (Brazil) cocoa polyphenols (decaffeinated/detheobrominated); C-7 = ICS-139: horti race = Trinitario (Nicaraguan Criollo ancestor) and description is crude extracts of ICS-139 (Brazil) cocoa polyphenols (decaffeinated/detheobrominated); C-8 = UIT-1: horti race = Trinitario and description is crude extracts of UIT-1 (Malaysia) cocoa polyphenols (decaffeinated/detheobrominated);

Fig. 15L shows the growth inhibition of Hela cells when treated with crude polyphenol extracts obtained from fermented cocoa beans and dried cocoa beans (stages throughout fermentation and sun drying; % control vs.

concentration,  $\mu\text{g/mL}$ ; open circle is day zero fraction, darkened circle is day 1 fraction, open inverted triangle is day 2 fraction, darkened inverted triangle is day 3 fraction, open square is day 4 fraction and darkened square is day 9 fraction);

Fig. 15M shows the effect of enzymatically oxidized cocoa procyanidins against Hela cells (dose response for polyphenol oxidase treated crude cocoa polyphenol; % control vs. concentration,  $\mu\text{g/mL}$ ; darkened square is crude UIT-1 (with caffeine and theobromine), open circle crude UIT-1 (without caffeine and theobromine) and darkened circle is crude UIT-1 (polyphenol oxidase catalyzed);

Fig. 15N shows a representative semi- preparative reverse phase HPLC separation for combined cocoa procyanidin fractions D and E;

Fig. 15O shows a representative normal phase semi-preparative HPLC separation of a crude cocoa polyphenol extract;

Fig. 16 shows typical Rancimat Oxidation curves for cocoa procyanidin extract and fractions in comparison to the synthetic antioxidants BHA and BHT (arbitrary units vs. time; dotted line and cross (+) is BHA and BHT; \* is D-E; x is crude; open square is A-C; and open diamond is control);

Fig. 17 shows a typical Agarose Gel indicating inhibition of topoisomerase II catalyzed decatenation of kinetoplast DNA by cocoa procyanidin fractions (Lane 1 contains  $0.5\mu\text{g}$  of marker (M) monomer-length kinetoplast DNA circles; Lanes 2 and 20 contain kinetoplast DNA that was incubated with Topoisomerase II in the presence of 4% DMSO, but in the absence of any cocoa procyanidins. (Control -C); Lanes 3 and 4 contain kinetoplast DNA that was incubated

with Topoisomerase II in the presence of 0.5 and 5.0  $\mu\text{g/mL}$  cocoa procyanidin fraction A; Lanes 5 and 6 contain kinetoplast DNA that was incubated with Topoisomerase II in the presence of 0.5 and 5.0  $\mu\text{g/mL}$  cocoa procyanidin fraction B; Lanes 7, 8, 9, 13, 14 and 15 are replicates of kinetoplast DNA that was incubated with Topoisomerase II in the presence of 0.05, 0.5 and 5.0  $\mu\text{g/mL}$  cocoa procyanidin fraction D; Lanes 10, 11, 12, 16, 17 and 18 are replicates of kinetoplast DNA that was incubated with Topoisomerase II in the presence of 0.05, 0.5, and 5.0  $\mu\text{g/mL}$  cocoa procyanidin fraction E; Lane 19 is a replicate of kinetoplast DNA that was incubated with Topoisomerase II in the presence of 5.0  $\mu\text{g/mL}$  cocoa procyanidin fraction E);

Fig. 18 shows dose response relationships of cocoa procyanidin fraction D against DNA repair competent and deficient cell lines (fractional survival vs.  $\mu\text{g/mL}$ ; left side xrs-6 DNA Deficient Repair Cell Line, MM-1 D D282X1; right side BR1 Competent DNA Repair Cell Line, MM-1 D D282B1);

Fig. 19 shows the dose-response curves for Adriamycin resistant MCF-7 cells in comparison to a MCF-7 p168 parental cell line when treated with cocoa fraction D+E (% control vs. concentration,  $\mu\text{g/mL}$ ; open circle is MCF-7 p168; darkened circle is MCF-7 ADR);

Figs. 20A and B show the dose-response effects on Hela and SKBR-3 cells when treated at 100  $\mu\text{g/mL}$  and 25  $\mu\text{g/mL}$  levels of twelve fractions prepared by Normal phase semi-preparative HPLC (bar chart, % control vs. control and fractions 1-12);

Fig. 21 shows a normal phase HPLC separation of crude, enriched and purified pentamers from cocoa extract;

Figs. 22A, B and C show MALDI-TOF/MS of pentamer enriched procyanidins, and of Fractions A-C and of Fractions D-E, respectively;

Fig. 23A shows an elution profile of oligomeric procyanidins purified by modified semi-preparative HPLC;

Fig. 23B shows an elution profile of a trimer procyanidin by modified semi-preparative HPLC;

Figs. 24A-D each show energy minimized structures of all (4-8) linked pentamers based on the structure of epicatechin;

Fig. 25A shows relative fluorescence of epicatechin upon thiolysis with benzylmercaptan;

Fig. 25B shows relative fluorescence of catechin upon thiolysis with benzylmercaptan;

Fig. 25C shows relative fluorescence of dimers (B2 and B5) upon thiolysis with benzylmercaptan;

Fig. 26A shows relative fluorescence of dimer upon thiolysis;

Fig. 26B shows relative fluorescence of B5 dimer upon thiolysis of dimer and subsequent desulphurization;

Fig. 27A shows the relative tumor volume during treatment of MDA MB 231 nude mouse model treated with pentamer;

Fig. 27B shows the relative survival curve of pentamer treated MDA 231 nude mouse model;

Fig. 28 shows the elution profile from halogen-free analytical separation of acetone extract of procyanidins from cocoa extract;

Fig. 29 shows the effect of pore size of stationary phase for normal phase HPLC separation of procyanidins;

Fig. 30A shows the substrate utilization during fermentation of cocoa beans;

Fig. 30B shows the metabolite production during fermentation;

5 Fig. 30C shows the plate counts during fermentation of cocoa beans;

Fig. 30D shows the relative concentrations of each component in fermented solutions of cocoa beans;

10 Fig. 31 shows the acetylcholine-induced relaxation of NO-related phenylephrine-precontracted rat aorta;

Fig. 32 shows the blood glucose tolerance profiles from various test mixtures;

Figs. 33A-B show the effects of indomethacin on COX-1 and COX-2 activities;

15 Figs. 34A-B show the correlation between the degree of polymerization and  $IC_{50}$  vs. COX-1/COX-2 ( $\mu M$ );

Fig. 35 shows the correlation between the effects of compounds on COX-1 and COX-2 activities expressed as  $\mu M$ ;

20 Figs. 36A-V show the  $IC_{50}$  values ( $\mu M$ ) of samples containing procyanidins with COX-1/COX-2;

Fig. 37 shows the purification scheme for the isolation of procyanidins from cocoa;

Fig. 38A to 38P shows the preferred structures of the pentamer;

25 Figs. 39A-AA show a library of stereoisomers of pentamers;

Figs. 40A-B show 70 minute gradients for normal phase HPLC separation of procyanidins, detected by UV and fluorescence, respectively;

30 Figs. 41A-B show 30 minute gradients for normal phase HPLC separation of procyanidins, detected by UV and fluorescence, respectively;

Fig. 42 shows a preparation normal phase HPLC separation of procyanidins;

Figs. 43A-G show CD (circular dichroism) spectra of procyanidin dimers, trimers, tetramers, pentamers, hexamers, heptamers and octamers, respectively;

Fig. 44A shows the structure and  $^1\text{H}/^{13}\text{C}$  NMR data for epicatechin;

Figs. 44B-F show the APT, COSY, XHCORR,  $^1\text{H}$  and  $^{13}\text{C}$  NMR spectra for epicatechin;

Fig. 45A shows the structure and  $^1\text{H}/^{13}\text{C}$  NMR data for catechin;

Figs. 45B-E show the  $^1\text{H}$ , APT, XHCORR and COSY NMR spectra for catechin;

Fig. 46A shows the structure and  $^1\text{H}/^{13}\text{C}$  NMR data for B2 dimer;

Figs. 46B-G show the  $^{13}\text{C}$ , APT,  $^1\text{H}$ , HMQC, COSY and HOHAHA NMR spectra for the B2 dimer;

Fig. 47A shows the structure and  $^1\text{H}/^{13}\text{C}$  NMR data for B5 dimer;

Figs. 47B-G show the  $^1\text{H}$ ,  $^{13}\text{C}$ , APT, COSY, HMQC and HOHAHA NMR spectra for B5 dimer;

Figs. 48A-D show the  $^1\text{H}$ , COSY, HMQC and HOHAHA NMR spectra for epicatechin/catechin trimer; and

Figs. 49A-D show the  $^1\text{H}$ , COSY, HMQC and HOHAHA NMR spectra for epicatechin trimer.

#### DETAILED DESCRIPTION

As discussed above, it has now been surprisingly found that cocoa extracts or a compound therefrom exhibit anti-cancer, anti-tumor or antineoplastic activity, antioxidant activity, inhibit DNA topoisomerase II enzyme and have antimicrobial, cyclo-oxygenase and/or lipxygenase, NO or NO-synthase and blood or *in vivo* glucose modulating



activities. The extracts or compound therefrom are generally prepared by reducing cocoa beans to a powder, defatting the powder, and extracting and purifying the active compound(s) from the defatted powder. The powder can  
5 be prepared by freeze-drying the cocoa beans and pulp, depulping and dehulling the freeze-dried cocoa beans and grinding the dehulled beans. The extraction of active compound(s) can be by solvent extraction techniques. The extracts can be purified; for instance, by gel permeation  
10 chromatography or by preparative High Performance Liquid Chromatography (HPLC) techniques or by a combination of such techniques. An outline of the purification protocol utilized in the isolation of substantially pure procyanidins is shown in Fig. 37. Steps 1 and 2 of the purification  
15 scheme are described in Examples 1 and 2; steps 3 and 4 are described in Examples 3, 13 and 23; step 5 is described in Examples 4 and 14; and step 6 is described in Examples 4, 14 and 16. The skilled artisan would appreciate and envision modifications in the purification scheme outlined in Figure  
20 37 to obtain the active compounds without departing from the spirit or scope thereof and without undue experimentation. The extracts or compound therefrom having activity, without wishing to necessarily be bound by any particular theory, have been identified as cocoa polyphenol(s) such as  
25 procyanidins. These cocoa procyanidins have significant anti-cancer, anti-tumor or antineoplastic activity; antioxidant activity; and inhibit DNA topoisomerase II enzyme; possess antimicrobial activity; and can modulate cyclo-oxygenase and/or lipooxygenase, NO or NO-synthase, and  
30 blood or *in vivo* glucose.

As recited above, the invention involves certain inventive compounds displaying the utilities noted above for

cocoa extracts; and, throughout this disclosure, the term "cocoa extract" may be substituted by an inventive compound disclosed above, such that it is to be understood that an inventive compound can be the cocoa extract. Preferred  
5 inventive compounds are shown in Fig. 38A to 38P, and Fig. 39A to 39V show a library of stereoisomers of the pentamer from which other compounds within the scope of the invention may be obtained without undue experimentation.

Anti-cancer, anti-tumor or antineoplastic or,  
10 antioxidant, DNA topoisomerase II enzyme inhibiting, antimicrobial, cyclo-oxygenase and/or lipoxxygenase modulator NO- or NO-synthase and blood or *in vivo* glucose modulating activities, or compositions containing the inventive cocoa polyphenols or procyanidins can be prepared in accordance  
15 with standard techniques well known to those skilled in the pharmaceutical or food science or veterinary art(s).

Such compositions can be administered to a subject or patient in need of such administration in dosages and by techniques well known to those skilled in the medical,  
20 nutritional or veterinary arts taking into consideration such factors as the age, sex, weight, and condition of the particular subject or patient, and the route of administration. The compositions can be co-administered or sequentially administered with other antineoplastic, anti-  
25 tumor or anti-cancer agents, antioxidants, DNA topoisomerase II enzyme inhibiting agents, or cyclo-oxygenase and/or lipoxxygenase, blood or *in vivo* glucose or NO or NO-synthase modulating agents and/or with agents which reduce or alleviate ill effects of antineoplastic, anti-tumor, anti-  
30 cancer agents, antioxidants, DNA topoisomerase II enzyme inhibiting agents, cyclo-oxygenase and/or lipoxxygenase, blood or *in vivo* glucose or NO or NO-synthase modulating

agents; again, taking into consideration such factors as the age, sex, weight, and condition of the particular subject or patient, and, the route of administration.

Examples of compositions of the invention include  
5 edible compositions for oral administration such solid or liquid formulations, for instance, capsules, tablets, pills and the like, as well as chewable solid or beverage formulations, to which the present invention may be well-suited since it is from an edible source (e.g., cocoa or  
10 chocolate flavored solid or liquid compositions); liquid preparations for orifice, e.g., oral, nasal, anal, vaginal etc., administration such as suspensions, syrups or elixirs (including cocoa or chocolate flavored compositions); and, preparations for parental, subcutaneous, intradermal,  
15 intramuscular or intravenous administration (e.g., injectable administration) such as sterile suspensions or emulsions. However, the active ingredient in the compositions may complex with proteins such that when administered into the bloodstream, clotting may occur due to  
20 precipitation of blood proteins; and, the skilled artisan should take this into account. In such compositions the active cocoa extract may be in admixture with a suitable carrier, diluent, or excipient such as sterile water, physiological saline, glucose, DMSO, ethanol, or the like.  
25 The active cocoa extract of the invention can be provided in lyophilized form for reconstituting, for instance, in isotonic aqueous, saline, glucose or DMSO buffer. In certain saline solutions, some precipitation has been observed; and, this observation may be employed as a means  
30 to isolate inventive compounds, e.g., by a "salting out" procedure.

Further, the invention also comprehends a kit wherein the active cocoa extract is provided. The kit can include a separate container containing a suitable carrier, diluent or excipient. The kit can also include an  
5 additional anti-cancer, anti-tumor or antineoplastic agent, antioxidant, DNA topoisomerase II enzyme inhibitor or antimicrobial, or cyclo-oxygenase and/or lipoxxygenase, NO or NO-synthase or blood or *in vivo* glucose modulating agent and/or an agent which reduces or alleviates ill effects of  
10 antineoplastic, anti-tumor or anti-cancer agents, antioxidant, DNA topoisomerase II enzyme inhibitor or antimicrobial, or cyclo-oxygenase and/or lipoxxygenase, NO or NO-synthase and blood or *in vivo* glucose modulating agents for co- or sequential-administration. The additional  
15 agent(s) can be provided in separate container(s) or in admixture with the active cocoa extract. Additionally, the kit can include instructions for mixing or combining ingredients and/or administration.

Furthermore, while the invention is described with  
20 respect to cocoa extracts preferably comprising cocoa procyanidins, from this disclosure the skilled organic chemist will appreciate and envision synthetic routes to obtain the active compounds. Accordingly, the invention comprehends synthetic cocoa polyphenols or procyanidins or  
25 their derivatives which include, but are not limited to glycosides, gallates, esters, etc. and the like. That is, the inventive compounds can be prepared from isolation from cocoa or from any species within the *Theobroma* or *Herrania* genera, as well as from synthetic routes; and derivatives of  
30 the inventive compounds such as glycosides, gallates, esters, etc. are included in the inventive compounds. Also, with reference to isolation from cocoa, any species of

- Theobroma* or *Herrania* or their inter- and intra- specific crosses thereof may be employed therefor, and reference in this regard is made to Schultes, "Synopsis of *Herrania*," Journal of the Arnold Arboretum, Vol. XXXIX, pp. 217 to 278 plus plates I to XVII (1958), Cuatrecasas, "Cacao and its Allies A Taxonomic Revision of the Genus *Theobroma*," Bulletin of the United States National Museum, Vol. 35, part 6, pp. 379 to 613, plus plates 1 to 11 (Smithsonian Institution 1964), and Addison et al., "Observations on the Species of the Genus *Theobroma* Which Occurs in the Amazon," Bol. Tech. Inst. Agronomico do Nortes, 25, 3 (1951).

The following non-limiting Examples are given by way of illustration only and are not to be considered a limitation of this invention, many apparent variations of which are possible without departing from the spirit or scope thereof.

#### EXAMPLES

##### Example 1: Cocoa Source and Method of Preparation

Several *Theobroma cacao* genotypes which represent the three recognized horticultural races of cocoa (Enriquez, 1967; Engels, 1981) were obtained from the three major cocoa producing origins of the world. A list of those genotypes used in this study are shown in Table 1. Harvested cocoa pods were opened and the beans with pulp were removed for freeze drying. The pulp was manually removed from the freeze dried mass and the beans were subjected to analysis as follows. The unfermented, freeze dried cocoa beans were first manually dehulled, and ground to a fine powdery mass with a TEKMAR Mill. The resultant mass was then defatted overnight by Soxhlet extraction using redistilled hexane as the solvent. Residual solvent was removed from the defatted mass by vacuum at ambient temperature.

Table 1: Description of *Theobroma cacao* Source Material

GENOTYPE	ORIGIN	HORTICULTURAL RACE
UIT-1	Malaysia	Trinitario
Unknown	West Africa	Forastero
ICS-100	Brazil	Trinitario (Nicaraguan Criollo ancestor)
ICS-39	Brazil	Trinitario (Nicaraguan Criollo ancestor)
UF-613	Brazil	Trinitario
EEG-48	Brazil	Forastero
UF-12	Brazil	Trinitario
NA-33	Brazil	Forastero

Example 2: Procyanidin Extraction ProceduresA. Method 1

Procyanidins were extracted from the defatted, unfermented, freeze dried cocoa beans of Example 1 using a modification of the method described by Jalal and Collin (1977). Procyanidins were extracted from 50 gram batches of the defatted cocoa mass with 2X 400 mL 70% acetone/deionized water followed by 400mL 70% methanol/deionized water. The extracts were pooled and the solvents removed by evaporation at 45°C with a rotary evaporator held under partial vacuum. The resultant aqueous phase was diluted to 1L with deionized water and extracted 2X with 400mL CHCl<sub>3</sub>. The solvent phase was discarded. The aqueous phase was then extracted 4X with 500mL ethyl acetate. Any resultant emulsions were broken by

centrifugation on a Sorvall RC 28S centrifuge operated at 2,000 xg for 30 min. at 10°C. To the combined ethyl acetate extracts, 100-200mL deionized water was added. The solvent was removed by evaporation at 45°C with a rotary evaporator held under partial vacuum. The resultant aqueous phase was frozen in liquid N<sub>2</sub> followed by freeze drying on a LABCONCO Freeze Dry System. The yields of crude procyanidins that were obtained from the different cocoa genotypes are listed in Table 2.

Table 2: Crude Procyanidin Yields

GENOTYPE	ORIGIN	YIELDS (g)
UIT-1	Malaysia	3.81
Unknown	West Africa	2.55
ICS-100	Brazil	3.42
ICS-39	Brazil	3.45
UF-613	Brazil	2.98
EEG-48	Brazil	3.15
UF-12	Brazil	1.21
NA-33	Brazil	2.23

B. Method 2

Alternatively, procyanidins are extracted from defatted, unfermented, freeze dried cocoa beans of Example 1 with 70% aqueous acetone. Ten grams of defatted material was slurried with 100 mL solvent for 5-10 min. The slurry was centrifuged for 15 min. at 4°C at 3000 xg and the supernatant passed through glass wool. The filtrate was subjected to distillation under partial vacuum and the resultant aqueous phase frozen in liquid N<sub>2</sub>, followed by

freeze drying on a LABCONCO Freeze Dry System. The yields of crude procyanidins ranged from 15-20%.

Without wishing to be bound by any particular theory, it is believed that the differences in crude yields reflected variations encountered with different genotypes, geographical origin, horticultural race, and method of preparation.

**Example 3: Partial Purification of Cocoa Procyanidins**

**A. Gel Permeation Chromatography**

Procyanidins obtained from Example 2 were partially purified by liquid chromatography on Sephadex LH-20 (28 x 2.5 cm). Separations were aided by a step gradient from deionized water into methanol. The initial gradient composition started with 15% methanol in deionized water which was followed step wise every 30 min. with 25% methanol in deionized water, 35% methanol in deionized water, 70% methanol in deionized water, and finally 100% methanol. The effluent following the elution of the xanthine alkaloids (caffeine and theobromine) was collected as a single fraction. The fraction yielded a xanthine alkaloid free subfraction which was submitted to further subfractionation to yield five subfractions designated MM2A through MM2E. The solvent was removed from each subfraction by evaporation at 45°C with a rotary evaporator held under partial vacuum. The resultant aqueous phase was frozen in liquid N<sub>2</sub> and freeze dried overnight on a LABCONCO Freeze Dry System. A representative gel permeation chromatogram showing the fractionation is shown in Figure 1. Approximately, 100mg of material was subfractionated in this manner.

Figure 1: Gel Permeation Chromatogram of Crude Procyanidins on Sephadex LH-20



Chromatographic Conditions: Column; 28 x 2.5 cm Sephadex LH-20, Mobile Phase: Methanol/Water Step Gradient, 15:85, 25:75, 35:65, 70:30, 100:0 Stepped at 1/2 Hour Intervals, Flow Rate; 1.5mL/min, Detector; UV at  $\lambda_1 = 254$  nm and  $\lambda_2 =$   
5 365 nm, Chart Speed: 0.5mm/min, Column Load; 120mg.

B. Semi-preparative High Performance Liquid Chromatography (HPLC)

10 Method 1. Reverse Phase Separation

Procyanidins obtained from Example 2 and/or 3A were partially purified by semi-preparative HPLC. A Hewlett Packard 1050 HPLC System equipped with a variable wavelength detector, Rheodyne 7010 injection valve with  
15 1mL injection loop was assembled with a Pharmacia FRAC-100 Fraction Collector. Separations were effected on a Phenomenex Ultracarb™ 10  $\mu$  ODS column (250 x 22.5mm) connected with a Phenomenex 10  $\mu$  ODS Ultracarb™ (60 x 10 mm) guard column. The mobile phase composition was  
20 A = water; B = methanol used under the following linear gradient conditions: [Time, %A]; (0,85), (60,50), (90,0), and (110,0) at a flow rate of 5mL/min. Compounds were detected by UV at 254nm

A representative Semi-preparative HPLC trace is  
25 shown in Figure 15N for the separation of procyanidins present in fraction D + E. Individual peaks or select chromatographic regions were collected on timed intervals or manually by fraction collection for further purification and subsequent evaluation. Injection loads ranged from 25-100mg  
30 of material.

Method 2. Normal Phase Separation

Procyanidin extracts obtained from Examples 2 and/or 3A were partially purified by semi-preparative HPLC. A Hewlett Packard 1050 HPLC system, Millipore-Waters

Model 480 LC detector set at 254nm was assembled with a Pharmacia Frac-100 Fraction Collector set in peak mode. Separations were effected on a Supelco 5 $\mu$ m Supelcosil LC-Si column (250 x 10mm) connected with a Supelco 5 $\mu$ m Supelguard LC-Si guard column (20 x 4.6mm). Procyanidins were eluted by a linear gradient under the following conditions: (Time, %A, %B); (0,82,14), (30, 67.6, 28.4), (60, 46, 50), (65, 10, 86), (70, 10, 86) followed by a 10 min. re-equilibration. Mobile phase composition was A = dichloromethane; B = methanol; and C = acetic acid: water (1:1). A flow rate of 3mL/min was used. Components were detected by UV at 254nm, and recorded on a Kipp & Zonan BD41 recorder. Injection volumes ranged from 100-250 $\mu$ l of 10mg of procyanidin extracts dissolved in 0.25mL 70% aqueous acetone. A representative semi-preparative HPLC trace is shown in Figure 15 O. Individual peaks or select chromatographic regions were collected on timed intervals or manually by fraction collection for further purification and subsequent evaluation.

HPLC Conditions: 250 x 10mm Supelco Supelcosil LC-Si  
(5 $\mu$ m) Semipreparative Column  
20 x 4.6mm Supelco Supelcosil LC-Si  
(5 $\mu$ m) Guard Column

Detector: Waters LC  
Spectrophotometer Model  
480 @ 254nm

Flow rate: 3mL/min,  
Column Temperature: ambient,  
Injection: 250 $\mu$ L of 70% aqueous  
acetone extract.

Gradient: Time (min)	CH <sub>2</sub> Cl <sub>2</sub>	Methanol	Acetic Acid:H <sub>2</sub> O (1:1)
0	82	14	4
30	67.6	28.4	4
60	46	50	4
65	10	86	4
70	10	86	4

The fractions obtained were as follows:

FRACTION	TYPE
1	dimers
2	trimers
3	tetramers
4	pentamers
5	hexamers
6	heptamers
7	octamers
8	nonamers
9	decamers
10	undecamers
11	dodecamers
12	higher oligomers

Example 4: Analytical HPLC Analysis of Procyanidin Extracts

Method 1. Reverse Phase Separation

Procyanidin extracts obtained from Example 3 were filtered through a  $0.45\mu$  filter and analyzed by a Hewlett Packard 1090 ternary HPLC system equipped with a Diode Array detector and a HP model 1046A Programmable Fluorescence Detector. Separations were effected at  $45^{\circ}\text{C}$  on a Hewlett-Packard  $5\mu$  Hypersil ODS column ( $200 \times 2.1\text{mm}$ ). The flavanols and procyanidins were eluted with a linear gradient of 60% B into A followed by a column wash with B at a flow rate of  $0.3\text{mL/min}$ . The mobile phase composition was B = 0.5% acetic acid in methanol and A = 0.5% acetic acid in nanopure water.

Acetic acid levels in A and B mobile phases can be increased to 2%. Components were detected by fluorescence, where

$\lambda_{ex} = 276\text{nm}$  and  $\lambda_{em} = 316\text{nm}$  and by UV at 280nm.

Concentrations of (+)-catechin and (-)-epicatechin were determined relative to reference standard solutions.

Procyanidin levels were estimated by using the response factor for (-)-epicatechin. A representative HPLC chromatogram showing the separation of the various components is shown in Figure 2A for one cocoa genotype.

**HPLC Conditions:**

Column: 200 x 2.1mm Hewlett Packard  
Hypersil ODS (5 $\mu$ )

Guard column: 20 x 2.1mm Hewlett  
Packard Hypersil ODS (5 $\mu$ )

Detectors: Diode Array @ 280nm

Fluorescence  $\lambda_{ex} = 276\text{nm}$ ;  
 $\lambda_{em} = 316\text{nm}$ .

Flow rate: 0.3mL/min.

Column Temperature: 45°C

Gradient: Time (min)	0.5% Acetic Acid in nanopure water	0.5% Acetic acid in methanol
0	100	0
50	40	60
60	0	100

**Method 2. Normal Phase Separation**

Procyanidin extracts obtained from Examples 2 and/or 3 were filtered through a 0.45 $\mu$  filter and analyzed by a Hewlett Packard 1090 Series II HPLC system equipped

with a HP model 1046A Programmable Fluorescence detector and Diode Array detector. Separations were effected at 37°C on a 5 $\mu$  Phenomenex Lichrosphere® Silica 100 column (250 x 3.2mm) connected to a Supelco Supelguard LC-Si 5 $\mu$  guard column (20 x 4.6mm). Procyanidins were eluted by linear gradient under the following conditions: (Time, %A, %B); (0, 82, 14), (30, 67.6, 28.4), (60, 46, 50), (65, 10, 86), (70, 10, 86) followed by an 8 min. re-equilibration. Mobile phase composition was A=dichloromethane, B=methanol, and C=acetic acid: water at a volume ratio of 1:1. A flow rate of 0.5 mL/min. was used. Components were detected by fluorescence, where  $\lambda_{ex}$  = 276nm and  $\lambda_{em}$  = 316nm or by UV at 280 nm. A representative HPLC chromatogram showing the separation of the various procyanidins is shown in Figure 2B for one genotype. Similar HPLC profiles were obtained from other cocoa genotypes.

#### HPLC Conditions:

250 x 3.2mm Phenomenex Lichrosphere® Silica 100 column (5 $\mu$ ) 20 x 4.6mm Supelco Supelguard LC-Si (5 $\mu$ ) guard column  
 Detectors: Photodiode Array @ 280nm  
 Fluorescence  $\lambda_{ex}$  = 276nm;  
 $\lambda_{em}$  = 316nm.  
 Flow rate: 0.5 mL/min.  
 Column Temperature: 37°C

Gradient: Time (min.)	CH <sub>2</sub> -Cl <sub>2</sub>	Methanol	Acetic Acid/Water (1:1)
0	82	14	4
30	67.6	28.4	4
60	46	50	4
65	10	86	4
70	10	86	4

**Example 5: Identification of Procyanidins**

Procyanidins were purified by liquid chromatography on Sephadex LH-20 (28 x 2.5cm) columns followed by semi-preparative HPLC using a 10 $\mu$  Bondapak C18 (100 x 8mm) column or by semi-preparative HPLC using a 5 $\mu$  Supelcosil LC-Si (250 x 10mm) column.

Partially purified isolates were analyzed by Fast Atom Bombardment - Mass Spectrometry (FAB-MS) on a VG ZAB-T high resolution MS system using a Liquid Secondary Ion Mass Spectrometry (LSIMS) technique in positive and negative ion modes. A cesium ion gun was used as the ionizing source at 30kV and a "Magic Bullet Matrix" (1:1 dithiothreitol/dithioerythritol) was used as the proton donor.

Analytical investigations of these fractions by LSIMS revealed the presence of a number of flavan-3-ol oligomers as shown in Table 3.

**Table 3: LSIMS (Positive Ion) Data from Cocoa Procyanidin Fractions**

	Oligomer	(M + 1) <sup>+</sup> m/z	(M + Na) <sup>+</sup> m/z	Mol. Wt.
5	Monomers (catechins)	291	313	290
	Dimer(s)	577/579	599/601	576/578
	Trimer(s)	865/867	887/889	864/866
	Tetramer(s)	1155	1177	1154
10	Pentamer(s)	1443	1465	1442
	Hexamer(s)	1731	1753	1730
	Heptamer(s)	---	2041	2018
	Octamer(s)	---	2329	2306
	Nonamer(s)	---	2617	2594
15	Decamer(s)	---	2905	2882
	Undecamer(s)	---	---	3170
	Dodecamer(s)	---	---	3458

The major mass fragment ions were consistent with work previously reported for both positive and negative ion FAB-MS analysis of procyanidins (Self et al., 1986 and Porter et al., 1991). The ion corresponding to  $m/z$  577  $(M+H)^+$  and its sodium adduct at  $m/z$  599  $(M+Na)^+$  suggested the presence of doubly linked procyanidin dimers in the isolates. It was interesting to note that the higher oligomers were more likely to form sodium adducts  $(M+Na)^+$  than their protonated molecular ions  $(M+H)^+$ . The procyanidin isomers B-2, B-5 and C-1 were tentatively identified based on the work reported by Revilla et al. (1991), Self et al. (1986) and Porter et al. (1991). Procyanidins up to both the octamer and decamer were



verified by FAB-MS in the partially purified fractions. Additionally, evidence for procyanidins up to the dodecamer were observed from normal phase HPLC analysis (see Figure 2B). Without wishing to be bound by any particular theory, it is believed that the dodecamer is the limit of solubility in the solvents used in the extraction and purification schemes. Table 4 lists the relative concentrations of the procyanidins found in xanthine alkaloid free isolates based on reverse phase HPLC analysis. Table 5 lists the relative concentrations of the procyanidins based on normal phase HPLC analysis.

Table 4: Relative Concentrations of Procyanidins in the Xanthine Alkaloid Free Isolates

Component	Amount
(+)-catechin	1.6%
(-)-epicatechin	38.2%
B-2 Dimer	11.0%
B-5 Dimer	5.3%
C-1 Trimer	9.3%
Doubly linked dimers	3.0%
Tetramer(s)	4.5%
Pentamer-Octamer	24.5%
Unknowns and higher oligomers	2.6%

**Table 5: Relative Concentrations of Procyanidins in Aqueous Acetone Extracts**

Component	Amount
(+)-catechin and (-) -epicatechin	41.9%
B-2 and B-5 Dimers	13.9%
Trimers	11.3%
Tetramers	9.9%
Pentamers	7.8%
Hexamers	5.1%
Heptamers	4.2%
Octamers	2.8%
Nonamers	1.6%
Decamers	0.7%
Undecamers	0.2%
Dodecamers	<0.1%

Figure 3 shows several procyanidin structures and Figures 4A-4E show the representative HPLC chromatograms of the five fractions employed in the following screening for anti-cancer or antineoplastic activity. The HPLC conditions for Figs. 4A-4E were as follows:

HPLC Conditions: Hewlett Packard 1090 ternary  
HPLC System equipped with HP Model 1046A  
Programmable Fluorescence Detector.

Column: Hewlett Packard 5 $\mu$  Hypersil ODS (200 x 2.1mm) Linear Gradient of 60% B into A at a flow rate of 0.3mL/min. B = 0.5% acetic acid in methanol; A = 0.5% acetic acid in deionized water.  $\lambda_{ex}$  = 280nm;  $\lambda_{em}$  = 316nm.

Figure 15 O shows a representative semi-prep HPLC chromatogram of an additional 12 fractions employed in the screening for anticancer or antineoplastic activity (HPLC conditions stated above).

5    **Example 6:**      Anti-Cancer, Anti-Tumor or Antineoplastic Activity of Cocoa Extracts (Procyanidins)

The MTT (3-[4,5-dimethyl thiazol-2yl]-2,5-diphenyltetrazolium bromide) - microtiter plate tetrazolium cytotoxicity assay originally developed by Mosmann (1983) was used to screen test samples from Example 5. Test samples, standards (cisplatin and chlorambucil) and MTT reagent were dissolved in 100% DMSO (dimethyl sulfoxide) at a 10mg/mL concentration. Serial dilutions were prepared from the stock solutions. In the case of the test samples, dilutions ranging from 0.01 through 100µg/mL were prepared in 0.5% DMSO.

20 All human tumor cell lines were obtained from the American Type Culture Collection. Cells were grown as mono layers in alpha-MEM containing 10% fetal bovine serum, 100 units/mL penicillin, 100 $\mu$ g/mL streptomycin and 240 units/mL nystatin. The cells were maintained in a humidified, 5% CO<sub>2</sub> atmosphere at 37°C.

After trypsinization, the cells are counted and adjusted to a concentration of  $50 \times 10^5$  cells/mL (varied according to cancer cell line). 200 $\mu$ L of the cell suspension was plated into wells of 4 rows of a 96-well microtiter plate. After the cells were allowed to attach for four hours, 2 $\mu$ L of DMSO containing test sample solutions were added to quadruplicate wells. Initial dose-response finding experiments, using order of magnitude test sample dilutions were used to determine the range of doses to be examined. Well absorbancies at 540nm were then measured on

a BIO RAD MP450 plate reader. The mean absorbance of quadruplicate test sample treated wells was compared to the control, and the results expressed as the percentage of control absorbance plus/minus the standard deviation. The  
5 reduction of MTT to a purple formazan product correlates in a linear manner with the number of living cells in the well. Thus, by measuring the absorbance of the reduction product, a quantitation of the percent of cell survival at a given dose of test sample can be obtained. Control wells  
10 contained a final concentration of 1% DMSO.

Two of the samples were first tested by this protocol. Sample MM1 represented a very crude isolate of cocoa procyanidins and contained appreciable quantities of caffeine and theobromine. Sample MM2 represented a cocoa  
15 procyanidin isolate partially purified by gel permeation chromatography. Caffeine and theobromine were absent in MM2. Both samples were screened for activity against the following cancer cell lines using the procedures previously described:

20 HCT 116 colon cancer  
ACHN renal adenocarcinoma  
SK-5 melanoma  
A498 renal adenocarcinoma  
MCF-7 breast cancer  
25 PC-3 prostate cancer  
CAPAN-2 pancreatic cancer

Little or no activity was observed with MM1 on any of the cancer cell lines investigated. MM2 was found to have activity against HCT-116, PC-3 and ACHN cancer cell  
30 lines. However, both MM1 and MM2 were found to interfere with MTT such that it obscured the decrease in absorbance that would have reflected a decrease in viable cell number.

This interference also contributed to large error bars, because the chemical reaction appeared to go more quickly in the wells along the perimeter of the plate. A typical example of these effects is shown in Figure 5. At the high concentrations of test material, one would have expected to observe a large decrease in survivors rather than the high survivor levels shown. Nevertheless, microscopic examinations revealed that cytotoxic effects occurred, despite the MTT interference effects. For instance, an  $IC_{50}$  value of  $0.5\mu\text{g/mL}$  for the effect of MM2 on the ACHN cell line was obtained in this manner.

These preliminary results, in the inventors' view, required amendment of the assay procedures to preclude the interference with MTT. This was accomplished as follows. After incubation of the plates at  $37^{\circ}\text{C}$  in a humidified, 5%  $\text{CO}_2$  atmosphere for 18 hours, the medium was carefully aspirated and replaced with fresh alpha-MEM media. This media was again aspirated from the wells on the third day of the assay and replaced with  $100\mu\text{L}$  of freshly prepared McCoy's medium.  $11\mu\text{L}$  of a  $5\text{mg/mL}$  stock solution of MTT in PBS (Phosphate Buffered Saline) were then added to the wells of each plate. After incubation for 4 hours in a humidified, 5%  $\text{CO}_2$  atmosphere at  $37^{\circ}\text{C}$ ,  $100\mu\text{L}$  of  $0.04\text{ N HCl}$  in isopropanol was added to all wells of the plate, followed by thorough mixing to solubilize the formazan produced by any viable cells. Additionally, it was decided to subfractionate the procyanidins to determine the specific components responsible for activity.

The subfractionation procedures previously described were used to prepare samples for further screening. Five fractions representing the areas shown in Figure 1 and component(s) distribution shown in Figures 4A -

4E were prepared. The samples were coded MM2A through MM2E to reflect these analytical characterizations and to designate the absence of caffeine and theobromine.

Each fraction was individually screened against the HCT-116, PC-3 and ACHN cancer cell lines. The results indicated that the activity did not concentrate to any one specific fraction. This type of result was not considered unusual, since the components in "active" natural product isolates can behave synergistically. In the case of the cocoa procyanidin isolate (MM2), over twenty detectable components comprised the isolate. It was considered possible that the activity was related to a combination of components present in the different fractions, rather than the activity being related to an individual component(s).

On the basis of these results, it was decided to combine the fractions and repeat the assays against the same cancer cell lines. Several fraction combinations produced cytotoxic effects against the PC-3 cancer cell lines. Specifically,  $IC_{50}$  values of  $40\mu\text{g/mL}$  each for MM2A and MM2E combination, and of  $20\mu\text{g/mL}$  each for MM2C and MM2E combination, were obtained. Activity was also reported against the HCT-116 and ACHN cell lines, but as before, interference with the MTT indicator precluded precise observations. Replicate experiments were repeatedly performed on the HCT-116 and ACHN lines to improve the data. However, these results were inconclusive due to bacterial contamination and exhaustion of the test sample material. Figures 6A-6D show the dose-response relationship between combinations of the cocoa extracts and PC-3 cancer cells.

Nonetheless, from this data, it is clear that cocoa extracts, especially cocoa polyphenols or procyanidins, have significant anti-tumor; anti-cancer or

antineoplastic activity, especially with respect to human PC-3 (prostate), HCT-116 (colon) and ACHN (renal) cancer cell lines. In addition, those results suggest that specific procyanidin fractions may be responsible for the activity against the PC-3 cell line.

Example 7: Anti-Cancer, Anti-Tumor or Antineoplastic Activity of Cocoa Extracts (Procyanidins)

To confirm the above findings and further study fraction combinations, another comprehensive screening was performed.

All prepared materials and procedures were identical to those reported above, except that the standard 4-replicates per test dose was increased to 8 or 12-replicates per test dose. For this study, individual and combinations of five cocoa procyanidin fractions were screened against the following cancer cell lines.

PC-3 Prostate  
KB Nasopharyngeal/HeLa  
HCT-116 Colon  
ACHN Renal  
MCF-7 Breast  
SK-5 Melanoma  
A-549 Lung  
CCRF-CEM T-cell leukemia

Individual screenings consisted of assaying different dose levels (0.01-100 $\mu$ g/mL) of fractions A, B, C, D, and E (See Figs. 4A-4E and discussion thereof, supra) against each cell line. Combination screenings consisted of combining equal dose levels of fractions A+B, A+C, A+D, A+E, B+C, B+D, B+E, C+D, C+E, and D+E against each cell line. The results from these assays are individually discussed, followed by an overall summary.

#### A. PC-3 Prostate Cell Line

Figures 7A - 7H show the typical dose response relationship between cocoa procyanidin fractions and the PC-3 cell line. Figures 7D and 7E demonstrate that fractions D and E were active at an  $IC_{50}$  value of 75  $\mu$ g/mL. The  $IC_{50}$  values that were obtained from dose-response curves of the other procyanidin fraction combinations ranged between 60 - 80  $\mu$ g/mL when fractions D or E were present. The individual  $IC_{50}$  values are listed in Table 6.

#### B. KB Nasopharyngeal/HeLa Cell Line

Figures 8A - 8H show the typical dose response relationship between cocoa procyanidin fractions and the KB Nasopharyngeal/HeLa cell line. Figures 8D and 8E demonstrate that fractions D and E were active at an  $IC_{50}$  value of 75  $\mu$ g/mL. Figures 8F - 8H depict representative results obtained from the fraction combination study. In this case, procyanidin fraction combination A+B had no effect, whereas fraction combinations B+E and D+E were active at an  $IC_{50}$  value of 60  $\mu$ g/mL. The  $IC_{50}$  values that were obtained from other dose response curves from other fraction combinations ranged from 60 - 80  $\mu$ g/mL when fractions D or E were present. The individual  $IC_{50}$  values are listed in Table 6. These results were essentially the same as those obtained against the PC-3 cell line.

#### C. HCT-116 Colon Cell Line

Figure 9A - 9H show the typical dose response relationships between cocoa procyanidin fractions and the HCT-116 colon cell line. Figures 9D and 9E demonstrate that fraction E was active at an  $IC_{50}$  value of approximately 400  $\mu$ g/mL. This value was obtained by extrapolation of the existing curve. Note that the slope of the dose response



curve for fraction D also indicated activity. However, no  $IC_{50}$  value was determined from this plot, since the slope of the curve was too shallow to obtain a reliable value.

Figures 9F - 9H depict representative results obtained from the fraction combination study. In this case, procyanidin fraction combination B+D did not show appreciable activity, whereas fraction combinations A+E and D+E were active at  $IC_{50}$  values of  $500\mu\text{g/mL}$  and  $85\mu\text{g/mL}$ , respectively. The  $IC_{50}$  values that were obtained from dose response curves of other fraction combinations averaged about  $250\mu\text{g/mL}$  when fraction E was present. The extrapolated  $IC_{50}$  values are listed in Table 6.

#### D. ACHN Renal Cell Line

Figure 10A - 10H show the typical dose response relationships between cocoa procyanidin fractions and the ACHN renal cell line. Figures 10A - 10E indicated that no individual fraction was active against this cell line. Figures 10F - 10H depict representative results obtained from the fraction combination study. In this case, procyanidin fraction combination B+C was inactive, whereas the fraction combination A+E resulted in an extrapolated  $IC_{50}$  value of approximately  $500\mu\text{g/mL}$ . Dose response curves similar to the C+D combination were considered inactive, since their slopes were too shallow. Extrapolated  $IC_{50}$  values for other fraction combinations are listed in Table 6.

#### E. A-549 Lung Cell Line

Figures 11A - 11H show the typical dose response relationships between cocoa procyanidin fractions and the A-549 lung cell line. No activity could be detected from any individual fraction or combination of fractions at the doses

used in the assay. However, procyanidin fractions may nonetheless have utility with respect to this cell line.

**F. SK-5 Melanoma Cell Line**

Figure 12A - 12H show the typical dose response relationships between cocoa procyanidin fractions and the SK-5 melanoma cell line. No activity could be detected from any individual fraction or combination of fractions at the doses used in the assay. However, procyanidin fractions may nonetheless have utility with respect to this cell line.

**G. MCF-7 Breast Cell Line**

Figures 13A - 13H show the typical dose response relationships between cocoa procyanidin fractions and the MCF-7 breast cell line. No activity could be detected from any individual fraction or combination of fractions at the doses used in the assay. However, procyanidin fractions may nonetheless have utility with respect to this cell line.

**H. CCRF-CEM T-Cell Leukemia Line**

A typical dose response curves were originally obtained against the CCRF-CEM T-cell leukemia line. However, microscopic counts of cell number versus time at different fraction concentrations indicated that 500  $\mu$ g of fractions A, B and D effected an 80% growth reduction over a four day period. A representative dose response relationship is shown in Figure 14.

**I. Summary**

The  $IC_{50}$  values obtained from these assays are collectively listed in Table 6 for all the cell lines except for CCRF-CEM T-cell leukemia. The T-cell leukemia data was intentionally omitted from the Table, since a different assay procedure was used. A general summary of these results indicated that the most activity was associated with fractions D and E. These fractions were most active against

the PC-3 (prostate) and KB (nasopharyngeal/HeLa) cell lines. These fractions also evidenced activity against the HCT-116 (colon) and ACHN (renal) cell lines, albeit but only at much higher doses. No activity was detected against the MCF-7 (breast), SK-5 (melanoma) and A-549 (lung) cell lines.

5. However, procyanidin fractions may nonetheless have utility with respect to these cell lines. Activity was also shown against the CCRF-CEM (T-cell leukemia) cell line. It should also be noted that fractions D and E are the most complex compositionally. Nonetheless, from this data it is clear  
10. that cocoa extracts, especially cocoa procyanidins, have significant anti-tumor, anti-cancer or antineoplastic activity.

**Table 6: IC<sub>50</sub> Values for Cocoa Procyanidin Fractions  
Against Various Cell Lines**

(IC<sub>50</sub> values in  $\mu\text{g/mL}$ )

FRACTION	PC-3	KB	HCT-116	ACHN	MCF-7	SK-5	A-549
A							
B							
C							
D	90	80					
E	75	75	400				
A+B							
A+C	125	100					
A+D	75	75					
A+E	80	75	500	500			
B+C							
B+D	75	80					
B+E	60	65	200				
C+D	80	75		1000			
C+E	80	70	250				
D+E	80	60	85				

Values above 100 $\mu\text{g/mL}$  were extrapolated from dose response curves

**Example 8. Anti-Cancer, Anti-Tumor or Antineoplastic  
Activity of Cocoa Extracts (Procyanidins)**

Several additional *in vitro* assay procedures were used to complement and extend the results presented in Examples 6 and 7.

#### Method A. Crystal Violet Staining Assay

All human tumor cell lines were obtained from the American Type Culture Collection. Cells were grown as monolayers in IMEM containing 10% fetal bovine serum without antibiotics. The cells were maintained in a humidified, 5% CO<sub>2</sub> atmosphere at 37°C.

After trypsinization, the cells were counted and adjusted to a concentration of 1,000-2,000 cells per 100 mL. Cell proliferation was determined by plating the cells (1,000-2,000 cells/well) in a 96 well microtiter plate. After addition of 100µL cells per well, the cells were allowed to attach for 24 hours. At the end of the 24 hour period, various cocoa fractions were added at different concentrations to obtain dose response results. The cocoa fractions were dissolved in media at a 2 fold concentration and 100µL of each solution was added in triplicate wells. On consecutive days, the plates were stained with 50µL crystal violet (2.5g crystal violet dissolved in 125mL methanol, 375mL water), for 15 min. The stain was removed and the plate was gently immersed into cold water to remove excess stain. The washings were repeated two more times, and the plates allowed to dry. The remaining stain was solubilized by adding 100µL of 0.1M sodium citrate/50% ethanol to each well. After solubilization, the number of cells were quantitated on an ELISA plate reader at 540nm (reference filter at 410nm). The results from the ELISA reader were graphed with absorbance on the y-axis and days growth on the x-axis.

#### Method B. Soft Agar Cloning Assay

Cells were cloned in soft agar according to the method described by Nawata et al. (1981). Single cell suspensions were made in media containing 0.8% agar with

various concentrations of cocoa fractions. The suspensions were aliquoted into 35mm dishes coated with media containing 1.0% agar. After 10 days incubation, the number of colonies greater than 60 $\mu$ m in diameter were determined on an  
5 Ominicron 3600 Image Analysis System. The results were plotted with number of colonies on the y-axis and the concentrations of a cocoa fraction on the x-axis.

Method C. XTT-Microculture Tetrazolium Assay

The XTT assay procedure described by Scudiero et  
10 al. (1988) was used to screen various cocoa fractions. The XTT assay was essentially the same as that described using the MTT procedure (Example 6) except for the following modifications. XTT ((2,3-bis(2-methoxy-4-nitro-5-sulfophenyl)-5-((phenylamino)carbonyl)-2H-tetrazolium  
15 hydroxide) was prepared at 1mg/mL medium without serum, prewarmed to 37°C. PMS was prepared at 5mM PBS. XTT and PMS were mixed together; 10 $\mu$ L of PMS per mL XTT and 50 $\mu$ L PMS-XTT were added to each well. After an incubation at 37°C for 4 hr, the plates were mixed 30 min. on a mechanical  
20 shaker and the absorbance measured at 450-600nm. The results were plotted with the absorbance on the y-axis and days growth or concentration on the x-axis.

For methods A and C, the results were also plotted as the percent control as the y-axis and days growth or  
25 concentration on the x-axis.

A comparison of the XTT and Crystal Violet Assay procedures was made with cocoa fraction D & E (Example 3B) against the breast cancer cell line MCF-7 p168 to determine which assay was most sensitive. As shown in Figure 15A,  
30 both assays showed the same dose-response effects for concentrations >75 $\mu$ g/mL. At concentrations below this value, the crystal violet assay showed higher standard

deviations than the XTT assay results. However, since the crystal violet assay was easier to use, all subsequent assays, unless otherwise specified, were performed by this procedure.

5           Crystal violet assay results are presented (Figures 15B-15E) to demonstrate the effect of a crude polyphenol extract (Example 2) on the breast cancer cell line MDA MB231, prostate cancer cell line PC-3, breast cancer cell line MCF-7 p163, and cervical cancer cell line  
10   Hela, respectively. In all cases a dose of 250 $\mu$ g/mL completely inhibited all cancer cell growth over a period of 5-7 days. The Hela cell line appeared to be more sensitive to the extract, since a 100 $\mu$ g/mL dose also inhibited growth. Cocoa fractions from Example 3B were also assayed against  
15   Hela and another breast cancer cell line SKBR-3. The results (Figures 15F and 15G) showed that fraction D & E has the highest activity. As shown in Figures 15H and 15I, IC<sub>50</sub> values of about 40 $\mu$ g/mL D & E were obtained from both cancer cell lines.

20           The cocoa fraction D & E was also tested in the soft agar cloning assay which determines the ability of a test compound(s) to inhibit anchorage independent growth. As shown in Figure 15J, a concentration of 100 $\mu$ g/mL completely inhibited colony formation of Hela cells.

25           Crude polyphenol extracts obtained from eight different cocoa genotypes representing the three horticultural races of cocoa were also assayed against the Hela cell line. As shown in Figure 15K all cocoa varieties showed similar dose-response effects. The  
30   UIT-1 variety exhibited the most activity against the Hela cell line. These results demonstrated that all cocoa genotypes possess a polyphenol fraction that elicits

activity against at least one human cancer cell line that is independent of geographical origin, horticultural race, and genotype.

Another series of assays were performed on crude  
5 polyphenol extracts prepared on a daily basis from a one ton  
scale traditional 5-day fermentation of Brazilian cocoa  
beans, followed by a 4-day sun drying stage. The results  
shown in Figure 15L showed no obvious effect of these early  
processing stages, suggesting little change in the  
10 composition of the polyphenols. However, it is known  
(Lehrian and Patterson, 1983) that polyphenol oxidase (PPO)  
will oxidize polyphenols during the fermentation stage. To  
determine what effect enzymatically oxidized polyphenols  
would have on activity, another experiment was performed.  
15 Crude PPO was prepared by extracting finely ground,  
unfermented, freeze dried, defatted Brazilian cocoa beans  
with acetone at a ratio of 1gm powder to 10mL acetone. The  
slurry was centrifuged at 3,000 rpm for 15 min. This was  
repeated three times, discarding the supernatant each time  
20 with the fourth extraction being poured through a Buchner  
filtering funnel. The acetone powder was allowed to air  
dry, followed by assay according to the procedures described  
by McLord and Kilara, (1983). To a solution of crude  
polyphenols (100mg/10mL Citrate-Phosphate buffer, 0.02M,  
25 pH 5.5) 100mg of acetone powder (4,000 units activity/mg  
protein) was added and allowed to stir for 30 min. with a  
stream of air bubbled through the slurry. The sample was  
centrifuged at 5,000xg for 15 min. and the supernatant  
extracted 3X with 20mL ethyl acetate. The ethyl acetate  
30 extracts were combined, taken to dryness by distillation  
under partial vacuum and 5mL water added, followed by  
lyophilization. The material was then assayed against Hela



cells and the dose-response compared to crude polyphenol extracts that were not enzymatically treated. The results (Figure 15M) showed a significant shift in the dose-response curve for the enzymatically oxidized extract, showing that the oxidized products were more inhibitory than their native forms.

**Example 9:            Antioxidant Activity of Cocoa Extracts Containing Procyanidins**

Evidence in the literature suggests a relationship between the consumption of naturally occurring antioxidants (Vitamins C, E and Beta-carotene) and a lowered incidence of disease, including cancer (Designing Foods, 1993; Caragay, 1992). It is generally thought that these antioxidants affect certain oxidative and free radical processes involved with some types of tumor promotion. Additionally, some plant polyphenolic compounds that have been shown to be anticarcinogenic, also possess substantial antioxidant activity (Ho et al., 1992; Huang et al., 1992).

To determine whether cocoa extracts containing procyanidins possessed antioxidant properties, a standard Rancimat method was employed. The procedures described in Examples 1, 2 and 3 were used to prepare cocoa extracts which were manipulated further to produce two fractions from gel permeation chromatography. These two fractions are actually combined fractions A through C, and D and E (See Figure 1) whose antioxidant properties were compared against the synthetic antioxidants BHA and BHT.

Peanut Oil was pressed from unroasted peanuts after the skins were removed. Each test compound was spiked into the oil at two levels, ~ 100 ppm and ~ 20 ppm, with the actual levels given in Table 7. 50µL of methanol solubilized antioxidant was added to each sample to aid in

dispersion of the antioxidant. A control sample was prepared with 50 $\mu$ L of methanol containing no antioxidant.

The samples were evaluated in duplicate, for oxidative stability using the Rancimat stability test at 100°C and 20 cc/min of air. Experimental parameters were chosen to match those used with the Active Oxygen Method (AOM) or Swift Stability Test (Van Oosten et al., 1981). A typical Rancimat trace is shown in Figure 16. Results are reported in Table 8 as hours required to reach a peroxide level of 100 meq.

Table 7: Concentrations of Antioxidants

SAMPLE	LEVEL 1	LEVEL 2
		ppm
Butylated Hydroxytoluene (BHT)	24	120
Butylated Hydroxyanisole (BHA)	24	120
Crude Ethyl Acetate Fraction of Cocoa	22	110
Fraction A-C	20	100
Fraction D-E	20	100

Table 8: Oxidative Stability of Peanut Oil with Various Antioxidants

SAMPLE	20 ppm	100 ppm
	average	
Control	10.5 ± 0.7	
BHT	16.5 ± 2.1	12.5 ± 2.1
BHA	13.5 ± 2.1	14.0 ± 1.4
Crude Cocoa Fraction	18.0 ± 0.0	19.0 ± 1.4

Fraction A-C	16.0 $\pm$ 6.4	17.5 $\pm$ 0.0
Fraction D-E	14.0 $\pm$ 1.4	12.5 $\pm$ 0.7

These results demonstrated increased oxidative stability of peanut oil with all of the additives tested. The highest increase in oxidative stability was realized by the sample spiked with the crude ethyl acetate extract of cocoa. These results demonstrated that cocoa extracts containing procyanidins have antioxidant potential equal to or greater than equal amounts of synthetic BHA and BHT. Accordingly, the invention may be employed in place of BHT or BHA in known utilities of BHA or BHT, for instance as an antioxidant and/or food additive. And, in this regard, it is noted too that the invention is from an edible source. Given these results, the skilled artisan can also readily determine a suitable amount of the invention to employ in such "BHA or BHT" utilities, e.g., the quantity to add to food, without undue experimentation.

**Example 10: Topoisomerase II Inhibition Study**

DNA topoisomerase I and II are enzymes that catalyze the breaking and rejoining of DNA strands, thereby controlling the topological states of DNA (Wang, 1985). In addition to the study of the intracellular function of topoisomerase, one of the most significant findings has been the identification of topoisomerase II as the primary cellular target for a number of clinically important antitumor compounds (Yamashita et al., 1990) which include intercalating agents (m-AMSA, Adriamycin® and ellipticine) as well as nonintercalating epipodophyllotoxins. Several lines of evidence indicate that some antitumor drugs have the common property of stabilizing the DNA - topoisomerase II complex ("cleavable complex") which upon exposure to

denaturing agents results in the induction of DNA cleavage (Muller et al., 1989). It has been suggested that the cleavable complex formation by antitumor drugs produces bulky DNA adducts that can lead to cell death.

5 According to this attractive model, a specific new inducer of DNA topoisomerase II cleavable complex is useful as an anti-cancer, anti-tumor or antineoplastic agent. In an attempt to identify cytotoxic compounds with activities that target DNA, the cocoa procyanidins were screened for  
10 enhanced cytotoxic activity against several DNA - damage sensitive cell lines and enzyme assay with human topoisomerase II obtained from lymphoma.

A. Decatenation of Kinetoplast DNA by Topoisomerase II

15 The *in vitro* inhibition of topoisomerase II decatenation of kinetoplast DNA, as described by Muller et al. (1989), was performed as follows. Nuclear extracts containing topoisomerase II activity were prepared from human lymphoma by modifications of the methods of Miller et  
20 al. (1981) and Danks et al. (1988). One unit of purified enzyme was enough to decatenate 0.25  $\mu$ g of kinetoplast DNA in 30 min. at 34°C. Kinetoplast DNA was obtained from the trypanosome *Crithidia fasciculata*. Each reaction was carried out in a 0.5mL microcentrifuge tube containing  
25 19.5 $\mu$ L H<sub>2</sub>O, 2.5 $\mu$ L 10X buffer (1X buffer contains 50mM tris-HCl, pH 8.0, 120mM KCl, 10mM MgCl<sub>2</sub>, 0.5mM ATP, 0.5mM dithiothreitol and 30 $\mu$ g BSA/mL), 1 $\mu$ L kinetoplast DNA (0.2 $\mu$ g), and 1 $\mu$ L DMSO-containing cocoa procyanidin test  
30 fractions at various concentrations. This combination was mixed thoroughly and kept on ice. One unit of topoisomerase was added immediately before incubation in a waterbath at 34°C for 30 min.

Following incubation, the decatenation assay was stopped by the addition of 5 $\mu$ L stop buffer (5% sarkosyl, 0.0025% bromophenol blue, 25% glycerol) and placed on ice. DNA was electrophoresed on a 1% agarose gel in TAE buffer containing ethidium bromide (0.5 $\mu$ g/mL). Ultraviolet illumination at 310nm wavelength allowed the visualization of DNA. The gels were photographed using a Polaroid Land camera.

Figure 17 shows the results of these experiments. Fully catenated kinetoplast DNA does not migrate into a 1% agarose gel. Decatenation of kinetoplast DNA by topoisomerase II generates bands of monomeric DNA (monomer circle, forms I and II) which do migrate into the gel. Inhibition of the enzyme by addition of cocoa procyanidins is apparent by the progressive disappearance of the monomer bands as a function of increasing concentration. Based on these results, cocoa procyanidin fractions A, B, D, and E were shown to inhibit topoisomerase II at concentrations ranging from 0.5 to 5.0 $\mu$ g/mL. These inhibitor concentrations were very similar to those obtained for mitoxanthrone and m-AMSA (4'-(9-acridinylamino)methanesulfon-m-anisidide).

#### B. Drug Sensitive Cell Lines

Cocoa procyanidins were screened for cytotoxicity against several DNA-damage sensitive cell lines. One of the cell lines was the xrs-6 DNA double strand break repair mutant developed by P. Jeggo (Kemp et al., 1984). The DNA repair deficiency of the xrs-6 cell line renders them particularly sensitive to x-irradiation, to compounds that produce DNA double strand breaks directly, such as bleomycin, and to compounds that inhibit topoisomerase II, and thus may indirectly induce double strand breaks as

suggested by Warters et al. (1991). The cytotoxicity toward the repair deficient line was compared to the cytotoxicity against a DNA repair proficient CHO line, BR1. Enhanced cytotoxicity towards the repair deficient (xrs-6) line was  
5 interpreted as evidence for DNA cleavable double strand break formation.

The DNA repair competent CHO line, BR1, was developed by Barrows et al. (1987) and expresses O<sup>6</sup>-alkylguanine - DNA - alkyltransferase in addition to normal  
10 CHO DNA repair enzymes. The CHO double strand break repair deficient line (xrs-6) was a generous gift from Dr. P. Jeggo and co-workers (Jeggo et al., 1989). Both of these lines were grown as monolayers in alpha-MEM containing serum and antibiotics as described in  
15 Example 6. Cells were maintained at 37°C in a humidified 5% CO<sub>2</sub> atmosphere. Before treatment with cocoa procyanidins, cells grown as monolayers were detached with trypsin treatment. Assays were performed using the MTT assay procedure described in Example 6.

20 The results (Figure 18) indicated no enhanced cytotoxicity towards the xrs-6 cells suggesting that the cocoa procyanidins inhibited topoisomerase II in a manner different from cleavable double strand break formation. That is, the cocoa procyanidins interact with topoisomerase  
25 II before it has interacted with the DNA to form a noncleavable complex.

Noncleavable complex forming compounds are relatively new discoveries. Members of the anthracyclines, podophyllin alkaloids, anthracenediones, acridines, and  
30 ellipticines are all approved for clinical anti-cancer, anti-tumor or antineoplastic use, and they produce cleavable complexes (Liu, 1989). Several new classes of topoisomerase

II inhibitors have recently been identified which do not appear to produce cleavable complexes. These include amonafide (Hsiang et al., 1989), distamycin (Fesen et al., 1989), flavanoids (Yamashita et al., 1990), saintopin  
5 (Yamashita et al., 1991), membranone (Drake et al., 1989), terpenoids (Kawada et al., 1991), anthrapyrazoles (Fry et al., 1985), dioxopiperazines (Tanabe et al., 1991), and the marine acridine - dercitin (Burres et al., 1989).

Since the cocoa procyanidins inactivate  
10 topoisomerase II before cleavable complexes are formed, they have chemotherapy value either alone or in combination with other known and mechanistically defined topoisomerase II inhibitors. Additionally, cocoa procyanidins also appear to be a novel class of topoisomerase II inhibitors, (Kashiwada  
15 et al., 1993) and may thus be less toxic to cells than other known inhibitors, thereby enhancing their utility in chemotherapy.

The human breast cancer cell line MCF-7 (ADR) which expresses a membrane bound glycoprotein (gp170) to  
20 confer multi-drug resistance (Leonessa et al., 1994) and its parental line MCF-7 p168 were used to assay the effects of cocoa fraction D & E. As shown in Figure 19, the parental line was inhibited at increasing dose levels of fraction D & E, whereas the Adriamycin (ADR) resistant line was less  
25 effected at the higher doses. These results show that cocoa fraction D & E has an effect on multi-drug resistant cell lines.

**Example 11: Synthesis of Procyanidins**

The synthesis of procyanidins was performed  
30 according to the procedures developed by Delcour et al. (1983), with modification. In addition to condensing

(+)-catechin with dihydroquercetin under reducing conditions, (-)-epicatechin was also used to reflect the high concentrations of (-)-epicatechin that naturally occur in unfermented cocoa beans. The synthesis products were isolated, purified, analyzed, and identified by the procedures described in Examples 3, 4 and 5. In this manner, the biflavanoids, triflavanoids and tetraflavanoids are prepared and used as analytical standards and, in the manner described above with respect to cocoa extracts.

Example 12: Assay of Normal Phase Semi-Preparative Fractions

Since the polyphenol extracts are compositionally complex, it was necessary to determine which components were active against cancer cell lines for further purification, dose-response assays and comprehensive structural identification. A normal phase semi preparative HPLC separation (Example 3B) was used to separate cocoa procyanidins on the basis of oligomeric size. In addition to the original extract, twelve fractions were prepared (Figures 2B and 15 O) and assayed at 100 $\mu$ g/mL and 25 $\mu$ g/mL doses against HeLa and SKBR-3 cancer cell lines to determine which oligomer possessed the greatest activity. As shown in Figures 20A and B, fractions 4-11 (pentamer-dodecamer) significantly inhibited HeLa and SKBr-3 cancer cell lines at the 100 $\mu$ g/mL level. These results indicated that these specific oligomers had the greatest activity against HeLa and SKBR-3 cells. Additionally, normal phase HPLC analysis of cocoa fraction D & E indicated that this fraction, used in previous investigations, e.g., Example 7, was enriched with these oligomers.



**Example 13: HPLC Purification Methods**  
**Method A. GPC Purification**

Procyanidins obtained as in Example 2 were partially purified by liquid chromatography on Sephadex LH  
5 20 (72.5 x 2.5cm), using 100% methanol as the eluting solvent, at a flow rate of 3.5mL/min. Fractions of the eluent were collected after the first 1.5 hours, and the fractions were concentrated by a rotary evaporator,  
10 referred to as pentamer enriched fractions. Approximately 2.00g of the extract obtained from Example 2 was subfractionated in this manner. Results are shown in Table 9.

Table 9: Composition of Fractions Obtained:

Fraction (line)	Monomer (% Area)	Dimer (% Area)	Trimer (% Area)	Tetramer (% Area)	Pentamer (% Area)	Hexamer (% Area)	Heptamer (% Area)	Octamer (% Area)	Nonamer (% Area)	Decamer (% Area)	Undecamer (% Area)	Others (% Area)
1:15	73	8	16	3	ND	ND	ND	ND	ND	ND	ND	ND
1:44	67	19	10	3	1	tr	tr	tr	tr	tr	tr	tr
2:13	30	29	24	11	4	1	tr	tr	tr	tr	tr	tr
2:42	2	16	31	28	15	6	2	tr	tr	tr	tr	tr
3:11	1	12	17	25	22	13	7	2	1	tr	tr	tr
3:40	tr	18	13	18	20	15	10	5	2	tr	tr	tr
4:09	tr	6	8	17	21	19	14	8	4	2	tr	tr

ND = not detected  
tr = trace amount

### Method B. Normal Phase Separation

Procyanidins obtained as Example 2 were separated purified by normal phase chromatography on Supelcosil LC-Si, 100Å, 5µm (250 x 4.6mm), at a flow rate of 1.0mL/min, or, in the alternative, Lichrosphere® Silica 100, 100Å, 5µm (235 x 3.2mm), at a flow rate of 0.5mL/min. Separations were aided by a step gradient under the following conditions: (Time, %A, %B); (0, 82, 14), (30, 67.6, 28.4), (60, 46, 50), (65, 10, 86), (70, 10, 86). Mobile phase composition was A = dichloromethane; B = methanol; and C = acetic acid:water (1:1). Components were detected by fluorescence where  $\lambda_{ex} = 276nm$  and  $\lambda_{em} = 316nm$ , and by UV at 280nm. The injection volume was 5.0µL (20mg/mL) of the procyanidins obtained from Example 2. These results are shown in Fig. 40A and 40B.

In the alternative, separations were aided by a step gradient under the following conditions: (Time, %A, %B); (0, 76, 20); (25, 46, 50); (30, 10, 86). Mobile phase composition was A = dichloromethane; B = methanol; and C = acetic acid : water (1:1). The results are shown in Fig. 41A and 41B.

### Method C. Reverse - Phase Separation

Procyanidins obtained as in Example 2 were separated purified by reverse phase chromatography on Hewlett Packard Hypersil ODS 5µm. (200 x 2.1mm), and a Hewlett Packard Hypersil ODS 5µm guard column (20 x 2.1mm). The procyanidins were eluted with a linear gradient of 20% B into A in 20 minutes, followed by a column wash with 100% B at a flow rate of 0.3mL/min. The mobile phase composition was a degassed mixture of B = 1.0% acetic acid in methanol and A = 2.0% acetic acid in nanopure water. Components were detected by UV at 280nm, and fluorescence where  $\lambda_{ex} = 276nm$

and  $\lambda_{em} = 316nm$ ; and the injection volume was  $2.0\mu l$  (20mg/mL).

**Example 14: HPLC Separation of Pentamer Enriched Fractions**

5

**Method A. Semi-Preparative Normal Phase HPLC**

The pentamer enriched fractions were further purified by semi-preparative normal phase HPLC by a Hewlett Packard 1050 HPLC system equipped with a Millipore - Waters  
10 model 480 LC detector set at 254nm, which was assembled with a Pharmacia Frac-100 Fraction Collector set to peak mode. Separations were effected on a Supelco  $5\mu m$  Supelcosel LC-Si, 100Å column (250 x 10mm) connected with a Supelco  $5\mu$  Supelguard LC-Si guard column (20 x 4.6mm). Procyanidins  
15 were eluted by a linear gradient under the following conditions: (Time, %A, %B); (0, 82, 14), (30, 67.6, 28.4), (60, 46, 50), (65, 10, 86), (70, 10, 86) followed by a 10 minute re-equilibration. Mobile phase composition was A = dichloromethane; B = methanol; and C = acetic acid:water  
20 (1:1). A flow rate of 3mL/min was used. Components were detected by UV at 254nm; and recorded on a Kipp & Zonan BD41 recorder. Injection volumes ranged from 100-250 $\mu l$  of 10mg of procyanidin extracts dissolved in 0.25mL 70% aqueous acetone. Individual peaks or select chromatographic regions  
25 were collected on timed intervals or manually by fraction collection for further purification and subsequent evaluation.

HPLC conditions: 250 x 100mm Supelco Supelcosil LC-Si  
(5 $\mu$ m) Semipreparative Column  
20 x 4.6mm Supelco Supelcosil LC-Si  
(5 $\mu$ m) Guard Column

Detector: Waters LC  
Spectrophotometer Model  
480 @ 254nm

Flow rate: 3mL/min.,  
Column Temperature: ambient,  
Injection: 250 $\mu$ l of pentamer enriched  
extract

Gradient:	CH <sub>2</sub> Cl <sub>2</sub>	methanol	acetic acid: water (1:1)
0	82	14	4
30	67.6	28.4	4
60	46	50	4
65	10	86	4
70	10	86	4

#### Method B. Reverse Phase Separation

Procyanidin extracts obtained as in Example 13 were filtered through a 0.45 $\mu$  nylon filter and analyzed by a Hewlett Packard 1090 ternary phase HPLC system equipped with a Diode Array detector and a HP model 1046A Programmable Fluorescence Detector. Separations were effected at 45°C on a Hewlett Packard 5 $\mu$  Hypersil ODS column (200 x 2.1mm). The procyanidins were eluted with a linear gradient of 60% B into A followed by a column wash with B at a flow rate of 0.3mL/min. The mobile phase composition was a de-gassed mixture of B = 0.5% acetic acid in methanol and A = 0.5% acetic acid in nanopure water. Acetic acid levels in A and B mobile phases can be increased to 2%. Components were detected by fluorescence, where  $\lambda_{ex}$  = 276nm and  $\lambda_{em}$  = 316nm, and by UV at 280nm. Concentrations of (+)-catechin and (-)-epicatechin were determined relative to reference standard

solutions. Procyanidin levels were estimated by using the response factor for (-)-epicatechin.

**Method C. Normal Phase Separation**

Pentamer enriched procyanidin extracts obtained as  
5 in Example 13 were filtered through a 0.45 $\mu$  nylon filter and  
analyzed by a Hewlett Packard 1090 Series II HPLC system  
equipped with a HP Model 1046A Programmable Fluorescence  
detector and Diode Array detector. Separations were  
effected at 37°C on a 5 $\mu$  Phenomenex Lichrosphere® Silica 100  
10 column (250 x 3.2mm) connected to a Supelco Supelguard LC-Si  
5 $\mu$  guard column (20 x 4.6mm). Procyanidins were eluted by  
linear gradient under the following conditions: (time, %A,  
%B); (0, 82, 14), (30, 67.6, 28.4), (60, 46, 50), (65, 10,  
86), (70, 10, 86), followed by an 8 minute re-equilibration.  
15 Mobile phase composition was A = dichloromethane, B =  
methanol, and C = acetic acid:water at a volume ratio of  
1:1. A flow rate of 0.5mL/min was used. Components were  
detected by fluorescence, where  $\lambda_{ex}$  = 276nm and  $\lambda_{em}$  = 316nm  
or by UV at 280nm. A representative HPLC chromatogram  
20 showing the separation of the various procyanidins is shown  
in Figure 2 for one genotype. Similar HPLC profiles were  
obtained from other *Theobroma*, *Herrania* and/or their inter  
or intra specific crosses.

**HPLC conditions:**

25 250 x 3.2mm Phenomenex Lichrosphere® Silica 100  
column (5 $\mu$ ) 20 x 4.6mm Supelco Supelguard LC-Si (5 $\mu$ )  
guard column  
Detectors: Photodiode Array @ 280nm  
Fluorescence  $\lambda_{ex}$  = 276nm;  $\lambda_{em}$  = 316nm  
30 Flow rate: 0.5 mL/min.  
Column temperature: 37°C

	Gradient:	<u>CH<sub>2</sub>Cl<sub>2</sub></u>		<u>methanol</u>		<u>acetic acid:</u>	
						<u>water (1:1)</u>	
	0	82		14		4	
	30	67.6		28.4		4	
5	60	46		50		4	
	65	10		86		4	
	70	10		86		4	

#### Method D. Preparative Normal Phase Separation

10 The pentamer enriched fractions obtained as in Example 13 were further purified by preparative normal phase chromatography by modifying the method of Rigaud et al., (1993) J. Chrom. 654, 255-260.

15 Separations were affected at ambient temperature on a 5 $\mu$  Supelcosil LC-Si 100Å column (50 x 2cm), with an appropriate guard column. Procyanidins were eluted by a linear gradient under the following conditions: (time, %A, %B, flow rate); (0, 92.5, 7.5, 10); (10, 92.5, 7.5, 40); (30, 91.5, 18.5, 40); (145, 88, 22, 40); (150, 24, 86, 40); (155, 24, 86, 50); (180, 0, 100, 50). Prior to use, the  
20 mobile phase components were mixed by the following protocol:

Solvent A preparation (82% CH<sub>2</sub>Cl<sub>2</sub>, 14% methanol, 2% acetic acid, 2% water):

1. Measure 80mL of water and dispense into a 4L  
25 bottle.
2. Measure 80mL of acetic acid and dispense into the same 4L bottle.
3. Measure 560mL of methanol and dispense into the same 4L bottle.
- 30 4. Measure 3280mL of methylene chloride and dispense into the 4L bottle.
5. Cap the bottle and mix well.
6. Purge the mixture with high purity Helium for 5-10 minutes to degas.

Repeat steps 1-6 two times to yield 8 volumes of solvent A.

Solvent B preparation (96% methanol, 2% acetic acid, 2% water):

- 5           1. Measure 80mL of water and dispense into a 4L bottle.
2. Measure 80mL of acetic acid and dispense into the same 4L bottle.
3. Measure 3840mL of methanol and dispense
- 10   3840mL of methanol and dispense into the same 4L bottle.
4. Cap the bottle and mix well.
5. Purge the mixture with high purity Helium for 5-10 minutes to degas.

Repeat steps 1-5 to yield 4 volumes of solvent B.

15   Mobile phase composition was A = methylene chloride with 2% acetic acid and 2% water; B = methanol with 2% acetic acid and 2% water. The column load was 0.7g in 7mL. components were detected by UV at 254nm. A typical preparative normal phase HPLC separation of cocoa procyanidins is shown in

20   Figure 42.

HPLC Conditions:

Column: 50 x 2cm 5 $\mu$  Supelcosil LC-Si run @ ambient temperature.

- 25           Mobile Phase: A = Methylene Chloride with 2% Acetic Acid and 2% Water.
- B = Methanol with 2% Acetic Acid and 2% Water.
- 30



## Gradient/Flow Profile:

TIME (MIN)	%A	%B	FLOW RATE (mL/min)
0	92.5	7.5	10
10	92.5	7.5	40
30	91.5	8.5	40
145	88.0	22.0	40
150	24.0	86.0	40
155	24.0	86.0	50
180	0.0	100.0	50

Example 15: Identification of Procyanidins

Procyanidins obtained as in Example 14, method D were analyzed by Matrix Assisted Laser Desorption Ionization-Time of Flight/Mass Spectrometry (MALDI-TOF/MS) using a HP G2025A MALDI-TOF/MS system equipped with a Lecroy 9350 500 MHz Oscilloscope. The instrument was calibrated in accordance with the manufacturer's instructions with a low molecular weight peptide standard (HP Part No. G2051A) or peptide standard (HP Part No. G2052A) with 2,5-dihydroxybenzoic acid (DHB) (HP Part No. G2056A) as the sample matrix. One (1.0) mg of sample was dissolved in 500 $\mu$ l of 70/30 methanol/water, and the sample was then mixed with DHB matrix, at a ratio of 1:1, 1:10 or 1:50 (sample:matrix) and dried on a mesa under vacuum. The samples were analyzed in the positive ion mode with the detector voltage set at 4.75kV and the laser power set between 1.5 and 8 $\mu$ J. Data was collected as the sum of a number of single shots and displayed as units of molecular weight and time of flight. A representative MALDI-TOF/MS is shown in Figure 22A.

Figures 22 and C show MALDI-TOF/MS spectra obtained from partially purified procyanidins prepared as described in Example 3, Method A and used for *in vitro* assessment as described in Examples 6 and 7, and whose results are summarized in Table 6. This data illustrates that the inventive compounds described herein were predominantly found in fractions D-E, but not A-C.

The spectra were obtained as follows:

The purified D-E fraction was subjected to MALDI-TOF/MS as described above, with the exception that the fraction was initially purified by SEP-PACK® C-18 cartridge. Five (5) mg of fraction D-E in 1 mL nanopure water was loaded onto a pre-equilibrated SEP-PACK® cartridge. The column was washed with 5mL nanopure water to eliminate contaminants, and procyanidins were eluted with 1mL 20% methanol. Fractions A-C were used directly, as they were isolated in Example 3, Method A, without further purification.

These results confirmed and extended earlier results (see Example 5, Table 3, Figs. 20A and B) and indicate that the inventive compounds have utility as sequestrants of cations. In particular, MALDI-TOF/MS results conclusively indicated that procyanidin oligomers of  $n = 5$  and higher (see Figures 20A and B; and formula under Objects and Summary of the Invention) were strongly associated with anti-cancer activity with the HeLa and SKBR-3 cancer cell line model. Oligomers of  $n = 4$  or less were ineffective with these models. The pentamer structure apparently has a structural motif which is present in it and in higher oligomers which provides the activity. Additionally, it was observed that the MALDI-TOF/MS data

showed strong M<sup>+</sup> ions of Na<sup>+</sup>, 2 Na<sup>+</sup>, K<sup>+</sup>, 2 K<sup>+</sup>, Ca<sup>++</sup>, demonstrating the utility as cation sequestrants.

**Example 16: Purification of Oligomeric Fractions**

**Method A. Purification by Semi-Preparative**

**Reverse Phase HPLC**

Procyanidins obtained from Example 14, Method A and B and D were further separated to obtain experimental quantities of like oligomers for further structural identification and elucidation (e.g., Example 15, 18, 19, and 20). A Hewlett Packard 1050 HPLC system equipped with a variable wavelength detector, Rheodyne 7010 injection valve with 1mL injection loop was assembled with a Pharmacia FRAC-100 Fraction Collector. Separations were effected on a Phenomenex Ultracarb<sup>®</sup> 10 $\mu$  ODS column (250 x 22.5mm) connected with a Phenomenex 10 $\mu$  ODS Ultracarb<sup>®</sup> (60 x 10mm) guard column. The mobile phase composition was A = water; B = methanol used under the following linear gradient conditions: (time, %A); (0,85), (60,50), (90,0 and (110,0) at a flow rate of 5 mL/min. Individual peaks or select chromatographic regions were collected on timed intervals or manually by fraction collection for further evaluation by MALDI-TOF/MS and NMR. Injection loads ranged from 25-100mg of material. A representative elution profile is shown in Fig. 23b.

**Method B. Modified Semi-Preparative HPLC**

Procyanidins obtained from Example 14, Method A and B and D were further separated to obtain experimental quantities of like oligomers for further structural identification and elucidation (e.g., Example 15, 18, 19, and 20). Supelcosil LC-Si 5 $\mu$  column (250 x 10mm) with a Supelcosil LC-Si 5 $\mu$  (20 x 2mm) guard column. The

separations were effected at a flow rate of 3.0mL/min, at ambient temperature. The mobile phase composition was A = dichloromethane; B = methanol; and C = acetic acid:water (1:1); used under the following linear gradient conditions:  
5 (time, %A, %B); (0, 82, 14); (22, 74, 21); (32, 74, 21); (60, 74, 50, 4); (61, 82, 14), followed by column re-equilibration for 7 minutes. Injection volumes were 60 $\mu$ l containing 12mg of enriched pentamer. Components were detected by UV at 280nm. A representative elution profile  
10 is shown in Figure 23A.

**Example 17: Molecular Modeling of Pentamers**

Energy minimized structures were determined by molecular modeling using Desktop Molecular Modeller, version 3.0, Oxford University Press, 1994. Four representative  
15 views of (EC(4  $\rightarrow$  8))<sub>4</sub>EC (EC = epicatechin) pentamers based on the structure of epicatechin are shown in Figures 24 A-D. A helical structure is suggested. In general when epicatechin is the first monomer and the bonding is 4-8, a beta configuration results, when the first monomer is  
20 catechin and the bonding is 4-8, an alpha configuration results; and, these results are obtained regardless of whether the second monomer is epicatechin or catechin (an exception is ent-EC(4  $\rightarrow$  8)ent-EC). Figures 38A - 38P show preferred pentamers, and, Figures 39A to 39P show a library  
25 of stereoisomers up to and including the pentamer, from which other compounds within the scope of the invention can be prepared, without undue experimentation.

**Example 18: NMR Evaluation of Pyrocyanidins**

<sup>13</sup>C NMR spectroscopy was deemed a generally useful  
30 technique for the study of procyanidins, especially as the phenols usually provide good quality spectra, whereas proton NMR spectra are considerably broadened. The <sup>13</sup>C NMR spectra

of oligomers yielded useful information for A or B ring substitution patterns, the relative stereochemistry of the C ring and in certain cases, the position of the interflavanoid linkages. Nonetheless, <sup>1</sup>H NMR spectra  
5 yielded useful information.

Further, HOHAHA, makes use of the pulse technique to transfer magnetization of a first hydrogen to a second in a sequence to obtain cross peaks corresponding to alpha, beta, gamma or delta protons. COSY is a 2D-Fourier  
10 transform NMR technique wherein vertical and horizontal axes provide <sup>1</sup>H chemical shift and 1D spectra; and a point of intersection provides a correlation between protons, whereby spin-spin couplings can be determined. HMQC spectra  
15 enhances the sensitivity of NMR spectra of nuclei; other than protons and can reveal cross peaks from secondary and tertiary carbons to the respective protons. APT is a <sup>13</sup>C technique used in determining the number of hydrogens present at a carbon. An even number of protons at a carbon will result in a positive signal, while an odd number of  
20 protons at a carbon will result in a negative signal.

Thus <sup>13</sup>C NMR, <sup>1</sup>H NMR, HOHAHA (homonuclear Hartmann-Hahn), HMQC (heteronuclear multiple quantum coherence), COSY (Homonuclear correlation spectroscopy), APT (attached proton test), and XHCORR (a variation on HMQC) spectroscopy were  
25 used to elucidate the structures of the inventive compounds.

#### Method A. Monomer

All spectra were taken in deuterated methanol, at room temperature, at an approximate sample concentration of 10mg/mL. Spectra were taken on a Bruker 500 MHz NMR, using  
30 methanol as an internal standard.

Figures 44A-E represent the NMR spectra which were used to characterize the structure of the epicatechin

monomer. Figure 44A shows the  $^1\text{H}$  and  $^{13}\text{C}$  chemical shifts, in tabular form. Figures 44 B-E show  $^1\text{H}$ , APT, XHCORR and COSY spectra for epicatechin.

Similarly, Figures 45A-F represent the NMR spectra which were used to characterize the structure of the catechin monomer. Figure 45A shows the  $^1\text{H}$  and  $^{13}\text{C}$  chemical shifts, in tabular form. Figures 44 B-F show  $^1\text{H}$ ,  $^{13}\text{C}$ , APT, XHCORR and COSY spectra for catechin.

#### Method B. Dimers

All spectra were taken in 75% deuterated acetone in  $\text{D}_2\text{O}$ , using acetone as an internal standard, and an approximate sample concentration of 10mg/mL.

Figures 46A-G represent the spectra which were used to characterize the structure of the B2 dimer. Fig. 46A shows  $^1\text{H}$  and  $^{13}\text{C}$  chemical shifts, in tabular form. The terms T and B indicate the top half of the dimer and the bottom half of the dimer.

Figures 46B and C show the  $^{13}\text{C}$  and APT spectra, respectively, taken on a Bruker 500 MHz NMR, at room temperature.

Figures 46D-G show the  $^1\text{H}$ , HMQC, COSY and HOHAHA, respectively, which were taken on AMZ-360 MHz NMR at a  $-7^\circ\text{C}$ . The COSY spectrum was taken using a gradient pulse.

Figures 47A-G represent the spectra which were used to characterize the structure of the B5 dimer. Figure 47A shows the  $^{13}\text{C}$  and  $^1\text{H}$  chemical shifts, in tabular form.

Figures 47B-D show the  $^1\text{H}$ ,  $^{13}\text{C}$  and APT, respectively, which were taken on a Bruker 500 MHz NMR, at room temperature.

Figure 47E shows the COSY spectrum, taken on an AMX-360, at room temperature, using a gradient pulse.

Figures 47F and G show the HMQC and HOHAHA, respectively, taken on an AMX-360 MHz NMR, at room temperature.

5                    Method C. Trimer - Epicatechin/Catechin

All spectra were taken in 75% deuterated acetone in D<sub>2</sub>O, at -3°C using acetone as an internal standard, on an AMX-360 MHz NMR, and an appropriate sample concentration of 10mg/mL.

10                   Figures 48A-D represent the spectra which were used to characterize the structure of the epicatechin/catechin trimer. These figures show <sup>1</sup>H, COSY, HMQC and HOHAHA, respectively. The COSY spectrum was taken using a gradient pulse.

15                   Method D. Trimer -All Epicatechin

All spectra were taken in 70% deuterated acetone in D<sub>2</sub>O, at -1.8°C, using acetone as an internal standard, on an AMX-360 MHz NMR, and an appropriate sample concentration of 10mg/mL.

20                   Figures 49A-D represent the spectra which were used to characterize the structure of all epicatechin trimer. These figures show <sup>1</sup>H, COSY, HMQC and HOHAHA, respectively. The COSY spectrum was taken using a gradient pulse.

25   **Example 19: Thiolysis of Procyanidins**

In an effort to characterize the structure of procyanidins, benzyl mercaptan (BM) was reacted with catechin, epicatechin or dimers B2 and B5. Benzyl mercaptan, as well as phloroglucinol and thiophenol, can be  
30 utilized in the hydrolysis (thiolysis) of procyanidins in an alcohol/acetic acid environment. Catechin, epicatechin or dimer (1:1 mixture of B2 and B5 dimers)(2.5mg) was dissolved

in 1.5mL ethanol, 100 $\mu$ l BM and 50 $\mu$ l acetic acid, and the vessel (Beckman amino acid analysis vessel) was evacuated and purged with nitrogen repeatedly until a final purge with nitrogen was followed by sealing the reaction vessel. The  
5 reaction vessel was placed in a heat block at 95°C, and aliquots of the reaction were taken at 30, 60, 120 and 240 minutes. The relative fluorescence of each aliquot is shown in Figures 25A-C, representing epicatechin, catechin and dimers, respectively. Higher oligomers are similarly  
10 thiolized.

**Example 20: Thiolysis and Desulfurization of Dimers**

Dimers B2 and B5 were hydrolyzed with benzylmercaptan by dissolving dimer (B2 or B5; 1.0 mg) in 600 $\mu$ l ethanol, 40 $\mu$ l BM and 20 $\mu$ l acetic acid. The mixture  
15 was heated at 95°C for 4 hours under nitrogen in a Beckman Amino Acid Analysis vessel. Aliquots were removed for analysis by reverse-phase HPLC, and 75 $\mu$ l of each of ethanol Raney Nickel and gallic acid (10mg/mL) were added to the remaining reaction medium in a 2mL hypovial. The vessel was  
20 purged under hydrogen, and occasionally shaken for 1 hour. The product was filtered through a 0.45 $\mu$  filter and analyzed by reverse-phase HPLC. Representative elution profiles are shown in Figures 26 A and B. Higher oligomers are similarly  
25 desulfurized. This data suggests polymerization of epicatechin or catechin and therefore represents a synthetic route for preparation of inventive compounds.

**Example 21: In vivo Activity of Pentamer in MDA MB 231 Nude Mouse Model**

30 **MDA-MB-231/LCC6 cell line.** The cell line was grown in improved minimal essential medium (IMEM) containing 10% fetal bovine serum and maintained in a humidified, 5% CO<sub>2</sub> atmosphere at 37°C.



Mice. Female six to eight week old NCr nu/nu (athymic) mice were purchased through NCI and housed in an animal facility and maintained according to the regulations set forth by the United States Department of Agriculture, and the American Association for the Accreditation of Laboratory Animal Care. Mice with tumors were weighed every other day, as well as weekly to determine appropriate drug dosing.

Tumor implantation. MDA-MD-231 prepared by tissue culture was diluted with IMEM to  $3.3 \times 10^6$  cells/mL and 0.15mL (i.e.  $0.5 \times 10^6$  cells) were injected subcutaneously between nipples 2 and 3 on each side of the mouse. Tumor volume was calculated by multiplying: length x width x height x 0.5. Tumor volumes over a treatment group were averaged and Student's t test was used to calculate p values.

Sample preparation. Plasma samples were obtained by cardiac puncture and stored at  $-70^\circ\text{C}$  with 15-20 mM EDTA for the purposes of blood chemistry determinations. No differences were noted between the control group and experimental groups.

Fifteen nude mice previously infected with 500,000 cells subcutaneously with tumor cell line MDA-MB- 231, were randomly separated into three groups of 5 animals each and treated by intraperitoneal injection with one of: (i) placebo containing vehicle alone (DMSO); (ii) 2mg/mouse of purified pentameric procyanidin extract as isolated in Example 14 method D in vehicle (DMSO); and (iii) 10mg/mouse purified pentameric procyanidin extract as isolated in Example 14, method D in vehicle (DMSO).

The group (iii) mice died within approximately 48 to 72 hours after administration of the 10mg, whereas the

group (ii) mice appeared normal. The cause of death of the group (iii) mice was undetermined; and, cannot necessarily be attributed to the administration of inventive compounds. Nonetheless, 10mg was considered an upper limit with respect to toxicity.

Treatment of groups (i) and (ii) was repeated once a week, and tumor growth was monitored for each experimental and control group. After two weeks of treatment, no signs of toxicity were observed in the mice of group (ii) and, the dose administered to this group was incrementally increased by 1/2 log scale each subsequent week. The following Table represents the dosages administered during the treatment schedule for mice of group (ii):

Week	Dose (mg/mouse)
1	2
2	2
3	4
4	5
5	5
6	5
7	5

The results of treatment are shown in Figures 27A and B and Table 10.

TABLE 10: IN VIVO ANTI-CANCER RESULTS

	DAY	% SURVIVAL GROUP (i)	% SURVIVAL GROUP (ii)	% SURVIVAL GROUP (iii)
5	1	100	100	100
	2	100	100	100
	3	100	100	0
	4	100	100	
	5	100	100	
10	6	100	100	
	7	100	100	
	8	100	100	
	9	100	100	
	10	100	100	
15	11	100	100	
	12	100	100	
	13	100	100	
	14	100	100	
	15	100	100	
20	16	100	100	
	17	100	100	
	18	100	100	
	19	100	100	
	20	100	100	
25	21	100	100	
	22	75	100	
	23	75	100	
	24	75	100	
	25	75	100	

	DAY	% SURVIVAL GROUP (i)	% SURVIVAL GROUP (ii)	% SURVIVAL GROUP (iii)
	26	75	100	
	27	75	100	
	28	75	100	
	29	50	100	
5	30	50	100	
	31	50	100	
	32	50	100	
	33	50	100	
	34	50	100	
10	35	50	100	
	36	25	100	
	37	25	100	
	38	25	100	
	39	25	100	
15	40	25	100	
	41	25	100	
	42	25	100	
	43	25	80	
	44	25	80	
20	45	25	80	
	46	25	80	
	47	25	80	
	48	25	80	
	49	25	80	
25	50	25	60	
	51	25	60	

DAY	% SURVIVAL GROUP (i)	% SURVIVAL GROUP (ii)	% SURVIVAL GROUP (iii)
52	25	60	
53	25	60	
54	25	60	
55	25	60	
56	25	60	
57	0	40	
58		40	
59		40	
60		40	
61		40	
62		40	
63		40	
64		40	

These results demonstrate that the inventive fractions and the inventive compounds indeed have utility in antineoplastic compositions, and are not toxic in low to medium dosages, with toxicity in higher dosages able to be determined without undue experimentation.

**Example 22: Antimicrobial Activity of Cocoa Extracts**

**Method A:**

A study was conducted to evaluate the antimicrobial activity of crude procyanidin extracts from cocoa beans against a variety of microorganisms important in food spoilage or pathogenesis. The cocoa extracts from Example 2, method A were used in the study. An agar medium appropriate for the growth of each test culture (99mL) was seeded with 1 mL of each cell culture suspension in 0.45% saline (final population  $10^2$  -  $10^4$  cfu/mL), and poured into

petri dishes. Wells were cut into hardened agar with a #2 cork borer (5mm diameter). The plates were refrigerated at 4°C overnight, to allow for diffusion of the extract into the agar, and subsequently incubated at an appropriate growth temperature for the test organism. The results were as follows:

Sample Zone of Inhibition (mm)

Extract Concentration (mg/mL)	<i>B. sphericus</i>	<i>B. cereus</i>	<i>S. aureus</i>	<i>P. aeruginosa</i>	<i>B. subtilis</i>
0	N1	N1	N1	N1	N1
25	N1	12	N1	11	N1
250	12	20	19	19	11
500	14	21	21	21	13

NI = no inhibition

Antimicrobial activity of purified procyanidin extracts from cocoa beans was demonstrated in another study using the well diffusion assay described above (in Method A) with *Staphylococcus aureus* as the test culture. The results were as follows:

cocoa extracts: 10mg/100  $\mu$ L decaffeinated/detheobrominated acetone extract as in Example 13, method A

10mg/100  $\mu$ L dimer (99% pure) as in Example 14, method D

10mg/100  $\mu$ L tetramer (95% pure) as in Example 14, method D

10mg/100  $\mu$ L hexamer (88% pure) as in Example 14, method D

10mg/100  $\mu$ L octamer/nanomer (92% pure) as in Example 14, method D

10mg/100  $\mu$ L nanomer & higher (87% pure)  
as in Example 14, method D

Sample Zone of Inhibition (mm)

5	0.45% saline	0
	Dimer	33
	Tetramer	27
	Hexamer	24
10	0.45% saline	0
	Octamer	22
	Nanomer	20
	Decaff./detheo.	26

15. Method B:

Crude procyanidin extract as in Example 2, method 2 was added in varying concentrations to TSB (Trypticase Soy Broth) with phenol red (0.08g/L), The TSB were inoculated with cultures of *Salmonella enteritidis* or *S. newport* ( $10^5$  cfu/mL), and were incubated for 18 hours at 35°C. The results were as follows:

	<u><i>S. enteritidis</i></u>	<u><i>S. Newport</i></u>
25	0mg/mL	+
	50	+
	100	+
	250	+
	500	-
30	750	-

where + = outgrowth, and - = no growth, as evidenced by the change in broth culture from red to yellow with acid production. Confirmation of inhibition was made by plating from TSB tubes onto XLD plates.

This Example demonstrates that the inventive compounds are useful in food preparation and preservation.

This Example further demonstrates that gram negative and gram positive bacterial growth can be inhibited by the inventive compounds. From this, the inventive

compounds can be used to inhibit *Helicobacter pylori*. *Helicobacter pylori* has been implicated in causing gastric ulcers and stomach cancer. Accordingly, the inventive compounds can be used to treat or prevent these and other maladies of bacterial origin. Suitable routes of administration, dosages, and formulations can be determined without undue experimentation considering factors well known in the art such as the malady, and the age, weight, sex, general health of the subject.

10 Example 23: Halogen-free Analytical Separation of Extract

Procyanidins obtained from Example 2 were partially purified by Analytical Separation by Halogen-free Normal Phase Chromatography on 100Å Supelcosil LC-Si 5µm (250 x 4.6mm), at a flow rate of 1.0mL/min, and a column temperature of 37°C. Separations were aided by a linear gradient under the following conditions: (time, %A, %B); (0, 82, 14); (30, 67.6, 28.4); (60, 46, 50). Mobile phase composition was A = 30/70 % diethyl ether/Toluene; B = Methanol; and C = acetic acid/water (1:1). Components were detected by UV at 280nm. A representative elution profile is shown in Figure 28.

25 Example 24: Effect of Pore Size of Stationary Phase for Normal Phase HPLC Separation of Procyanidins

To improve the separation of procyanidins, the use of a larger pore size of the silica stationary phase was investigated. Separations were effected on Silica-300, 5µm, 300Å (250 x 2.0mm), or, in the alternative, on Silica-1000, 5µm, 1000Å (250 x 2.0mm). A linear gradient was employed as mobile phase composition was: A = Dichloromethane; B = Methanol; and C = acetic acid/water (1:1). Components were detected by fluorescence, wherein  $\lambda_{ex}$  = 276nm and  $\lambda_{em}$  = 316nm, by UV detector at 280nm. The flow rate was



1.0mL/min, and the oven temperature was 37°C. A representative chromatogram from three different columns (100Å pore size, from Example 13, Method D) is shown in Figure 29. This shows effective pore size for separation of procyanidins.

**Example 25: Obtaining Desired Procyanidins Via Manipulating Fermentation**

Microbial strains representative of the succession associated with cocoa fermentation were selected from the M&M/Mars cocoa culture collection. The following isolates were used:

15 *Acetobacter aceti* ATCC 15973  
*Lactobacillus* sp. (BH 42)  
*Candida krusei* (BA 15)  
*Saccharomyces cerevisiae* (BA 13)  
*Bacillus cereus* (BE 35)  
*Bacillus sphaericus* (ME 12)

20 Each strain was transferred from stock culture to fresh media. The yeasts and *Acetobacter* were incubated 72 hours at 26°C and the bacilli and *Lactobacillus* were incubated 48 hours at 37°C. The slants were harvested with 5mL phosphate buffer prior to use.

25 Cocoa beans were harvested from fresh pods and the pulp and testa removed. The beans were sterilized with hydrogen peroxide (35%) for 20 seconds, followed by treatment with catalase until cessation of bubbling. The beans were rinsed twice with sterile water and the process  
30 repeated. The beans were divided into glass jars and processed according to the regimens detailed in the following Table:

Water	Ethanol/acid	Fermentation infusate	Model Fermentation
-------	--------------	--------------------------	-----------------------

daily transfer to fresh water	daily transfer to solutions of alcohol and acid corresponding to levels determined at each stage of a model pulp fermentation	daily transfer to fermented pulp pasteurized on each successive day of fermentation	bench scale model fermentation in sterile pulp coinoculated with test strains
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5

The bench scale fermentation was performed in duplicate. All treatments were incubated as indicated below:

- 10                   Day 1: 26°C  
                     Day 2: 26°C to 50°C  
                     Day 3: 50°C  
                     Day 4: 45°C  
                     Day 5: 40°C

- 15                   The model fermentation was monitored over the duration of the study by plate counts to assess the microbial population and HPLC analysis of the fermentation medium for the production of microbial metabolites. After treatment, the beans were dried under a laminar flow hood to a water activity of 0.64 and were roasted at 66°C for 15 min. Samples were prepared for procyanidin analysis. Three beans per treatment were ground and defatted with hexane, followed by extraction with an acetone:water:acetic acid (70:29.5:0.5%) solution. The acetone solution extract was filtered into vials and polyphenol levels were quantified by normal phase HPLC as in Example 13, method B. The remaining beans were ground and tasted. The cultural and analytical profiles of the model bench-top fermentation process is shown in Figures 30A - C. The procyanidin profiles of cocoa beans subjected to various fermentation treatments is shown in Figure 30D.
- 20
- 25
- 30

This Example demonstrates that the invention need not be limited to any particular cocoa genotype; and, that by manipulating fermentation, the levels of procyanidins produced by a particular *Theobroma* or *Herrania* species or  
5 their inter or intra species specific crosses thereof can be modulated, e.g., enhanced.

The following Table shows procyanidin levels determined in specimens which are representative of the *Theobroma* genus and their inter and intra species specific  
10 crosses. Samples were prepared as in Examples 1 and 2 (methods 1 and 2), and analyzed as in Examples 13, method B. This data illustrates that the extracts containing the inventive compounds are found in *Theobroma* and *Herrania* species, and their intra and inter species specific crosses.

Theobroma Species Procyandin Levels  
ppm (µg/g) in dehydrated powder

Oligomer											
SAMPLE	Moisture	Dens	Time	Isoprene	Proline	Hisidine	Asparagine	Glutamine	Alanine	Decarboxyl	Total
<i>T. grandiflorum</i> x <i>T. obovatum</i> 1'	3822	3442	5384	4074	3146	2080	850	421	348	198	23,765
<i>T. grandiflorum</i> x <i>T. obovatum</i> 2'	3003	4098	5411	3983	2931	1914	1090	577	356	198	23,561
<i>T. grandiflorum</i> x <i>T. obovatum</i> 3A'	4990	4980	7556	5341	4008	2576	1075	598	301	144	31,569
<i>T. grandiflorum</i> x <i>T. obovatum</i> 3B'	3880	4498	6488	4930	3706	2560	1208	593	323	174	28,360
<i>T. grandiflorum</i> x <i>T. obovatum</i> 4'	2647	3591	5320	4240	3304	2380	1506	815	506	249	24,566
<i>T. grandiflorum</i> x <i>T. obovatum</i> 6'	2754	3855	5299	3872	2994	1990	1158	629	359	196	23,194
<i>T. grandiflorum</i> x <i>T. obovatum</i> 5IN'	3212	4134	7608	4736	3590	2274	936	446	278	128	23,750
<i>T. obovatum</i> 1'	3662	5683	9512	5358	3858	2454	1207	640	302	144	32,820
<i>T. grandiflorum</i> TEFFE'	2608	2178	3090	2704	2241	1586	900	484	301	148	16,240
<i>T. grandiflorum</i> TEFFE x <i>T. grandiflorum</i> '	4773	4096	5289	4748	3804	2444	998	737	335	156	27,380
<i>T. grandiflorum</i> x <i>T. subincanum</i> '	4752	3336	4916	3900	3064	2039	782	435	380	228	23,832
<i>T. obovatum</i> x <i>T. subincanum</i> '	3379	3802	5836	3940	2868	1807	814	427	271	136	23,280
<i>T. speciosum</i> x <i>T. sylvestris</i> '	902	346	1350	217	152	120	60	11	11	ND	3,147
<i>T. microcarpum</i> '	5694	3250	2766	1490	822	356	141	11	ND	ND	14,519
<i>T. cacao</i> , SIAL 659, 10	21,929	10,072	10,106	7768	5311	3242	1311	626	422	146	60,753
<i>T. cacao</i> , SIAL 659, 124	21,088	9762	9119	7094	4774	2906	1364	608	361	176	57,252
<i>T. cacao</i> , SIAL 659, 148	20,887	9892	9474	7337	4906	2929	1334	692	412	302	58,165
<i>T. cacao</i> , SIAL 659, 196	9552	5780	5062	3360	2140	1160	464	254	138	11	27,910
<i>T. cacao</i> , SIAL 659, 1120	8581	4665	4070	2527	1628	888	326	166	123	11	22,974

\*ND = none detected' sample designated CPATU

\*1r = trace (< 50µg/g) sample designated ERJON

**Example 26: Effect of Procyanidins on NO**  
**Method A.**

The purpose of this study is to establish the relationship between procyanidins (as in Example 14, method D) and NO, which is known to induce cerebral vascular dilation. The effects of monomers and higher oligomers, in concentrations ranging from 100 $\mu$ g/mL to 0.1 $\mu$ g/mL, on the production of nitrates (the catabolites of NO), from HUVEC (human umbilical vein endothelial cells) is evaluated. HUVEC (from Clonetics) is investigated in the presence or absence of each procyanidin for 24 to 48 hours. At the end of the experiments, the supernatants are collected and the nitrate content determined by colorimetric assay. In separate experiments, HUVEC is incubated with acetylcholine, which is known to induce NO production, in the presence or absence of procyanidins for 24 to 48 hours. At the end of the experiments, the supernatants are collected and nitrate content is determined by colorimetric assay. The role of NO is ascertained by the addition of nitroarginine or (1)-N-methyl arginine, which are specific blockers of NO synthase.

**Method B. Vasorelaxation of Phenylephrine-Induced Contracted Rat Artery**

The effects of each of the procyanidins (100 $\mu$ g/mL to 0.1 $\mu$ g/mL on the rat artery is the target for study of vasorelaxation of phenylephrine-induced contracted rat artery. Isolated rat artery is incubated in the presence or absence of procyanidins (as in Example 14, method D) and alteration of the muscular tone is assessed by visual inspection. Both contraction or relaxation of the ray artery is determined. Then, using other organs, precontraction of the isolated rat artery is induced upon

addition of epinephrine. Once the contraction is stabilized, procyanidins are added and contraction or relaxation of the rat artery is determined. The role of NO is ascertained by the addition of nitroarginine or (1)-N-methyl arginine. The acetylcholine-induced relaxation of NO, as it is effected by phenylephrine-precontracted rat aorta is shown in Figure 31.

**Method C. Induction of Hypotension in the Rat**

This method is directed to the effect of each procyanidin (as in Example 14, method D) on blood pressure. Rats are instrumented in order to monitor systolic and diastolic blood pressure. Each of the procyanidins are injected intravenously (dosage range = 100 - 0.1 $\mu$ g/kg), and alteration of blood pressure is assessed. In addition, the effect of each procyanidin on the alteration of blood pressure evoked by epinephrine is determined. The role of NO is ascertained by the addition of nitroarginine or (1)-N-methyl arginine.

These studies, together with next Example, illustrate that the inventive compounds are useful in modulating vasodilation, and are further useful with respect to modulating blood pressure or addressing coronary conditions, and migraine headache conditions.

**Example 27: Effects of Cocoa Polyphenols on Satiety**

Using blood glucose levels as an indicator for the signal events which occur in vivo for the regulation of appetite and satiety, a series of simple experiments were conducted using a healthy male adult volunteer age 48 to determine whether cocoa polyphenols would modulate glucose levels. Cocoa polyphenols were partially purified from Brazilian cocoa beans according to the methods described by

Clapperton et al. (1992). This material contained no caffeine or theobromine. Fasting blood glucose levels were analyzed on a timed basis after ingestion of 10 fl. oz of Dexicola 75 (caffeine free) Glucose tolerance test beverage (Curtin Matheson 091-421) with and without 75mg cocoa polyphenols. This level of polyphenols represented 0.1% of the total glucose of the test beverage and reflected the approximate amount that would be present in a standard 100g chocolate bar. Blood glucose levels were determined by using the Accu-Chek III blood glucose monitoring system (Boehringer Mannheim Corporation). Blood glucose levels were measured before ingestion of test beverage, and after ingestion of the test beverage at the following timed intervals: 15, 30, 45, 60, 75, 90, 120 and 180 minutes. Before the start of each glucose tolerance test, high and low glucose level controls were determined. Each glucose tolerance test was performed in duplicate. A control test solution containing 75mg cocoa polyphenols dissolved in 10 fl. oz. distilled water (no glucose) was also performed.

Table 11 below lists the dates and control values obtained for each glucose tolerance experiment performed in this study. Figure 32 represents plots of the average values with standard deviations of blood glucose levels obtained throughout a three hour time course. It is readily apparent that there is a substantial increase in blood sugar levels was obtained after ingestion of a test mixture containing cocoa polyphenols. The difference between the two principal glucose tolerance profiles could not be resolved by the profile obtained after ingestion of a solution of cocoa polyphenols alone. The addition of cocoa polyphenols to the glucose test beverage raised the glucose tolerance profile significantly. This elevation in blood

glucose levels is within the range considered to be mildly diabetic, even though the typical glucose tolerance profile was considered to be normal (Davidson, I. et al., Eds. Todd - Sanford Clinical Diagnosis by Laboratory Methods 14th edition; W.B. Saunders Co.; Philadelphia, PA 1969 Ch. 10, pp. 550-9). This suggests that the difference in additional glucose was released to the bloodstream, from the glycogen stores, as a result of the inventive compounds. Thus, the inventive compounds can be used to modulate blood glucose levels when in the presence of sugars.

Table 11. Glucose Tolerance Test Dates and Control Results

WEEK	DESCRIPTION	HIGH CONTROL <sup>a</sup>	LOW CONTROL <sup>b</sup>
0	Glucose Tolerance	265 mg/dL	53 mg/dL
1	Glucose Tolerance with 0.1% polyphenols	310	68
2	Glucose Tolerance	315	66
4	Glucose Tolerance with 0.1% polyphenols	325	65
5	0.1% polyphenols	321	66

a = Expected range: 253 - 373mg/dL

b = Expected range: 50-80mg/dL



The subject also experienced a facial flush (erythemia) and lightheadedness following ingestion of the inventive compounds, indicating modulation of vasodilation.

- 5 The data presented in Tables 12 and 13 illustrates the fact that extracts of the invention pertaining to cocoa raw materials and commercial chocolates, and inventive compounds contained therein can be used as a vehicle for pharmaceutical, veterinary and food science preparations and applications.

Procyanidin Levels in Commercial Chocolates  
µg/g

Sample	Monomers	Dimers	Trimers	Tetramers	Pentamers	Hexamers	Heptamers and Higher	Total
Brand 1	366	166	113	59	56	23	18	801
Brand 2	344	163	111	45	48	ND*	ND	711
Brand 3	316	181	100	41	40	7	ND	685
Brand 4	310	122	71	27	28	5	ND	563
Brand 5	259	135	90	46	29	ND	ND	559
Brand 6	308	139	91	57	47	14	ND	656
Brand 7	196	98	81	58	54	19	ND	506
Brand 8	716	472	302	170	117	18	ND	1,795
Brand 9	1,185	951	633	298	173	25	21	3,286
Brand 10	1,798	1,081	590	342	307	93	ND	4,211
Brand 11	1,101	746	646	372	347	130	75	3,417
Brand 12	787	335	160	20	10	8	ND	1,320

ND\* = None detected.

Procyanidin Levels in Cocoa Raw Materials  
µg/g

Sample	Monomers	Dimers	Trimers	Tetramers	Pentamers	Hexamers	Heptamers and Higher	Total
Unfermented	13,440	6,425	6,401	5,292	4,236	3,203	5,913	44,910
Fermented	2,695	1,538	1,362	740	470	301	277	7,383
Roasted	2,656	1,597	921	337	164	ND*	ND	5,675
Choc. Liquor	2,805	1,446	881	442	184	108	ND	5,866
Cocoa Hulls	114	53	14	ND	ND	ND	ND	181
Cocoa Powder 1% Fat	506	287	112	ND	ND	ND	ND	915
Cocoa Powder 11% Fat	1,523	1,224	680	46	ND	ND	ND	3,473
Red Dutch Cocoa Powder, pH 7.4, 11% fat	1,222	483	103	ND	ND	ND	ND	1,808
Red Dutch Cocoa Powder, pH 8.2, 23% fat	168	144	60	ND	ND	ND	ND	372

ND\* = None detected.

**Example 28:**            The Effect of Procyanidins on  
                              Cyclooxygenase 1 & 2

The effect of procyanidins on cyclooxygenase 1 & 2 (COX1/COX2) activities was assessed by incubating the enzymes, derived from ram seminal vesicle and sheep placenta, respectively, with arachidonic acid ( $5\mu\text{M}$ ) for 10 minutes at room temperature, in the presence of varying concentrations of procyanidin solutions containing monomer to decamer and procyanidin mixture. Turnover was assessed by using PGE2 EIA kits from Interchim (France). Indomethacin was used as a reference compound. The results are presented in the following Table, wherein the  $\text{IC}_{50}$  values are expressed in units of  $\mu\text{M}$  (except for S11, which represents a procyanidin mixture prepared from Example 13, Method A and where the the samples S1 to S10 represent sequentially procyanidin oligomers (monomer through decamer) as in Example 14, Method D, and  $\text{IC}_{50}$  is expressed in units of  $\text{mg/mL}$ ).

SAMPLE #	IC <sub>50</sub> COX-1 (°)	IC <sub>50</sub> COX-2 (°)	RATIO IC <sub>50</sub> COX2/COX1
1	0.074	0.197	2.66
2	0.115	0.444	3.86
3	0.258	0.763	2.96
4	0.154	3.73	24.22
5	0.787	3.16	4.02
6	1.14	1.99	1.75
7	1.89	4.06	2.15
8	2.25	7.2	3.20
9	2.58	2.08	0.81
10	3.65	3.16	0.87
11	0.0487	0.0741	1.52
Indomethoacin	0.599	13.5	22.54

15 (°) expressed as mM with the exception of sample 11,  
which is mg/mL.

The results of the inhibition studies are presented in Figures 33 A and B, which shows the effects of Indomethacin on COX1 and COX2 activities. Figures 34 A and B shows the correlation between the degree of polymerization of the procyanidin and IC<sub>50</sub> with COX1 and COX2; Figure 35 shows the correlation between IC<sub>50</sub> values on COX1 and COX2. And, Figures 36 A through Y show the IC<sub>50</sub> values of each sample (S1 - S11) with COX1 and COX2.

These results indicate that the inventive compounds have analgesic, anti-coagulant, and anti-inflammatory utilities. Further, COX2 has been linked to colon cancer. Inhibition of COX2 activity by the inventive

COX1 and COX2 are also implicated in the synthesis of prostaglandins. Thus, the results in this Example also indicate that the inventive compounds can modulate renal functions, immune responses, fever, pain, mitogenesis, apoptosis, prostaglandin synthesis, ulceration (e.g., gastric), and reproduction. Note that modulation of renal function can affect blood pressure; again implicating the inventive compounds in modulating blood pressure, vasodilation, and coronary conditions (e.g., modulation of angiotensin, bradykinin).

Reference is further made to Examples 9, 26, and 27. In Example 9, the anti-oxidant activity of inventive compounds is shown. In Example 26, the effect on NO is demonstrated. And, Example 27 provides evidence of a facial vasodilation. From the results in this Example, in combination with Examples 9, 26 and 27, the inventive compounds can modulate free radical mechanisms driving physiological effects. Similarly, lipxygenase mediated free radical type reactions biochemically directed toward leukotriene synthesis can be modulated by the inventive

compounds, thus affecting subsequent physiological effects (e.g., inflammation, immune response, coronary conditions, carcinogenic mechanisms, fever, pain, ulceration).

Thus, in addition to having analgesic properties, there may also be a synergistic effect by the inventive compounds when administered with other analgesics. Likewise, in addition to having antineoplastic properties, there may also be a synergistic effect by the inventive compounds when administered with other antineoplastic agents.

**Example 29: Circular Dichroism/Study of Procyanidius**

CD studies were undertaken in an effort to elucidate the structure of purified procyanidins as in Example 14, Method D. The spectra were collected at 25°C using CD spectrum software AVIV 60DS V4.1f.

Samples were scanned from 300nm to 185nm, every 1.00nm, at 1.50nm bandwidth. Representative CD spectra are shown in Figures 43A through G, which show the CD spectra of dimer through octamer.

These results are indicative of the helical nature of the inventive compounds.

From the foregoing, it is clear that the extract and cocoa polyphenols, particularly the inventive compounds, as well as the compositions, methods, and kits, of the invention have significant and numerous utilities.

The antineoplastic utility is clearly demonstrated by the *in vivo* and *in vitro* data herein and shows that

inventive compounds can be used instead of or in conjunction with conventional antineoplastic agents.

The inventive compounds have antioxidant activity like that of BHT and BHA, as well as oxidative stability. Thus, the invention can be employed in place of or in conjunction with BHT or BHA in known utilities of BHA and BHT, such as an antioxidant, for instance, an antioxidant; food additive.

The invention can also be employed in place of or in conjunction with topoisomerase II-inhibitors in the presently known utilities therefor.

The inventive compounds can be used in food preservation or preparation, as well as in preventing or treating maladies of bacterial origin. Simply the inventive compoundss can be used as an antimicrobial.

The inventive compounds can also be used as a cyclo-oxygenase and/or lipxygenase, NO or NO-synthase, or blood or in vivo glucose modulator, and are thus useful for treatment or prevention or modulation of pain, fever, inflammation coronary conditions, ulceration, carcinogenic mechanisms, vasodilation, as well as an analgesic, anti-coagulant anti-inflammatory and an immune response modulator.

Further, the invention comprehends the use of the compounds or extracts as a vehicle for pharmaceutical preparations. Accordingly, there are many compositions and methods envisioned by the invention. For instance, antioxidant or preservative compositions, topoisomerase II-inhibiting compositions, methods for preserving food or any



desired item such as from oxidation, and methods for inhibiting topoisomerase II. The compositions can comprise the inventive compounds. The methods can comprise contacting the food, item or topoisomerase II with the  
5 respective composition or with the inventive compounds. Other compositions, methods and embodiments of the invention are apparent from the foregoing.

In this regard, it is mentioned that the invention is from an edible source and, that the activity *in vitro* can  
10 demonstrate at least some activity *in vivo*; and from the *in vitro* and *in vivo* data herein, doses, routes of administration, and formulations can be obtained without undue experimentation.

Having thus described in detail the preferred  
15 embodiments of the present invention, it is to be understood that the invention defined by the appended claims is not to be limited by particular details set forth in the above descriptions as many apparent variations thereof are possible without departing from the spirit or scope of the  
20 present invention.

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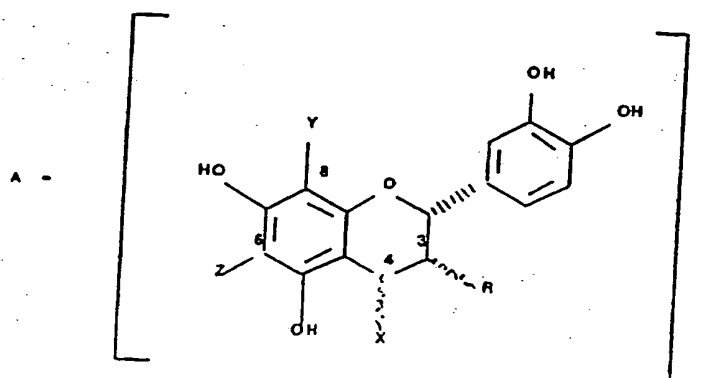
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WHAT IS CLAIMED IS:

1. A compound of the formula:



wherein:

$n$  is an integer from 3 to 12, such that there is a first monomeric unit A, and a plurality of other monomeric units;

R is 3-( $\alpha$ )-OH, 3-( $\beta$ )-OH, 3-( $\alpha$ )-O-sugar, or 3-( $\beta$ )-O-sugar;

position 4 is alpha or beta stereochemistry;

X, Y and Z represent positions for bonding between monomeric units, with the provisos that as to the first monomeric unit, bonding of another monomeric unit thereto is at position 4 and  $Y = Z = \text{hydrogen}$ , and, that when not for bonding monomeric units, X, Y and Z are hydrogen or Z, Y are sugar and X is hydrogen, or X is alpha or beta sugar and Z + Y are hydrogen, or combinations thereof; and



the sugar can be optionally substituted with a phenolic moiety via an ester bond.

2. The compound of claim 1 wherein n is 5.
3. The compound of claim 1 wherein the sugar is selected from the group consisting essentially of glucose, galactose, xylose, rhamnose and arabinose.
4. An antineoplastic composition comprising a compound of claim 1 and a carrier or diluent.
5. An antineoplastic composition comprising a compound of claim 2 and a carrier or diluent.
6. An antioxidant composition comprising a compound of claim 1 and a carrier or diluent.
7. An antioxidant composition comprising a compound of claim 2 and a carrier or diluent.
8. An antimicrobial composition comprising a compound of claim 1 and a carrier or diluent.
9. An antimicrobial composition comprising a compound of claim 2 and a carrier or diluent.
10. A cyclo-oxygenase and/or lipxygenase modulator composition comprising a compound of claim 1 and a carrier or diluent.
11. A cyclo-oxygenase and/or lipxygenase modulator composition comprising a compound of claim 2 and a carrier or diluent.

12. An NO or NO-synthase modulating composition comprising a compound of claim 1 and a carrier or diluent.
13. An NO or NO-synthase modulating composition comprising a compound of claim 2 and a carrier or diluent.
14. An *in vivo* glucose-modulating composition comprising a compound of claim 1 and a carrier or diluent.
15. An *in vivo* glucose-modulating composition comprising a compound of claim 2 and a carrier diluent.
16. A method for treating a subject in need of treatment with an antineoplastic agent comprising administering to the subject an antineoplastic composition of claim 4.
17. A method for treating a subject in need of treatment with an antineoplastic agent comprising administering to the subject an antineoplastic composition of claim 5.
18. A method for treating a subject in need of treatment with an antioxidant agent comprising administering to the subject an antioxidant composition of a compound of claim 6.
19. A method for treating a subject in need of treatment with an antioxidant agent comprising administering to the subject an antioxidant composition of a compound of claim 7.
20. A method for treating a subject in need of treatment with an antimicrobial agent comprising

administering to the subject an antimicrobial composition of a compound of claim 8.

21. A method for treating a subject in need of treatment with an antimicrobial agent comprising administering to the subject an antimicrobial composition of claim 9.

22. A method for treating a subject in need of treatment with a cyclo-oxygenase or lipoxxygenase modulating agent comprising administering to the subject a composition of claim 10.

23. A method for treating a subject in need of treatment with a cyclo-oxygenase or lipoxxygenase modulating agent comprising administering to the patient a composition of claim 11.

24. A method for treating a subject in need of treatment with a NO or NO-synthase modulating agent comprising administering to the subject a composition of claim 12.

25. A method for treating a subject in need of treatment with a NO-modulating agent comprising administering to the subject a NO or NO-synthase modulating composition of claim 12.

26. A method for treating a subject in need of treatment with a glucose-modulating agent comprising administering to the subject a composition of claim 14.

27. A method for treating a subject in need of treatment with a glucose-modulating agent comprising administering to the subject a composition of claim 15.

28. An antioxidant or preservative composition comprising a compound as claimed in claim 1 and a diluent.
29. An antioxidant or preservative composition comprising a compound as claimed in claim 2 and a diluent.
30. A topoisomerase II-inhibiting composition comprising a compound as claimed in claim 1 and a carrier or diluent.
31. A topoisomerase II-inhibiting composition comprising a compound as claimed in claim 2 and a carrier or diluent.
32. A method for preserving or protecting a desired item from oxidation comprising contacting the item with a composition as claimed in claim 28.
33. A method for inhibiting topoisomerase II which comprises contacting topoisomerase II with a composition as claimed in claim 30.
34. A carrier or vehicle for a pharmaceutical comprising a compound as claimed in claim 1.
35. A carrier or vehicle for a pharmaceutical comprising a cocoa extract.
36. A kit for a composition of claim 4 comprising the compound and the carrier or diluent separately packaged, and optionally instructions for admixture or administration.
37. A kit for a composition of claim 6 comprising the compound and the carrier or diluent separately packaged, and optionally instructions for admixture or administration.

38. A kit for a composition of claim 8 comprising the compound and the carrier or diluent separately packaged, and optionally instructions for admixture or administration.

39. A kit for a composition of claim 10 comprising the compound and the carrier or diluent separately packaged, and optionally instructions for admixture or administration.

40. A kit for a composition of claim 12 comprising the compound and the carrier or diluent separately packaged, and optionally instructions for admixture or administration.

41. A kit for a composition of claim 14 comprising the compound and the carrier or diluent separately packaged, and optionally instructions for admixture or administration.

42. A kit for a composition of claim 30 comprising the compound and the carrier or diluent separately packaged, and optionally instructions for admixture or administration.

43. A kit for a composition of claim 28 comprising the compound and the diluent separately packaged, and optionally instructions for admixture or use.

44. A substantially pure *Theobroma* or *Herrania* species or inter or their intra species specific crosses thereof extract comprising polyphenols comprising oligomers 3 through 12.

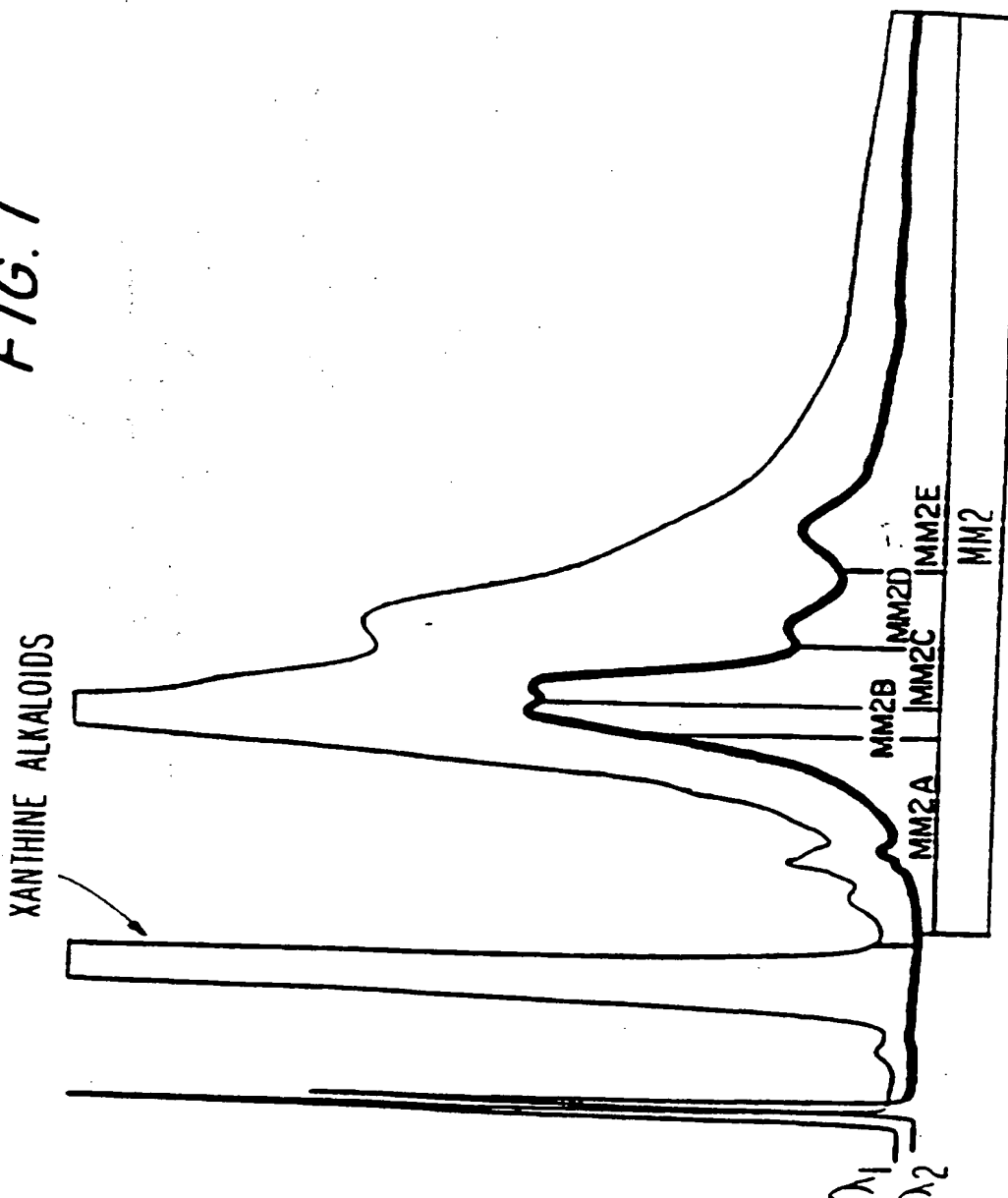
45. A compound of claim 1 having a structure giving an NMR spectra as set forth in Figure 48A-D.

46. A compound of claim 1 having a structure giving an NMR spectra as set forth in Figure 49A-D.

47. A method for enhancing the concentration levels and distribution of cocoa procyanidins in cocoa beans by manipulating fermentation conditions.

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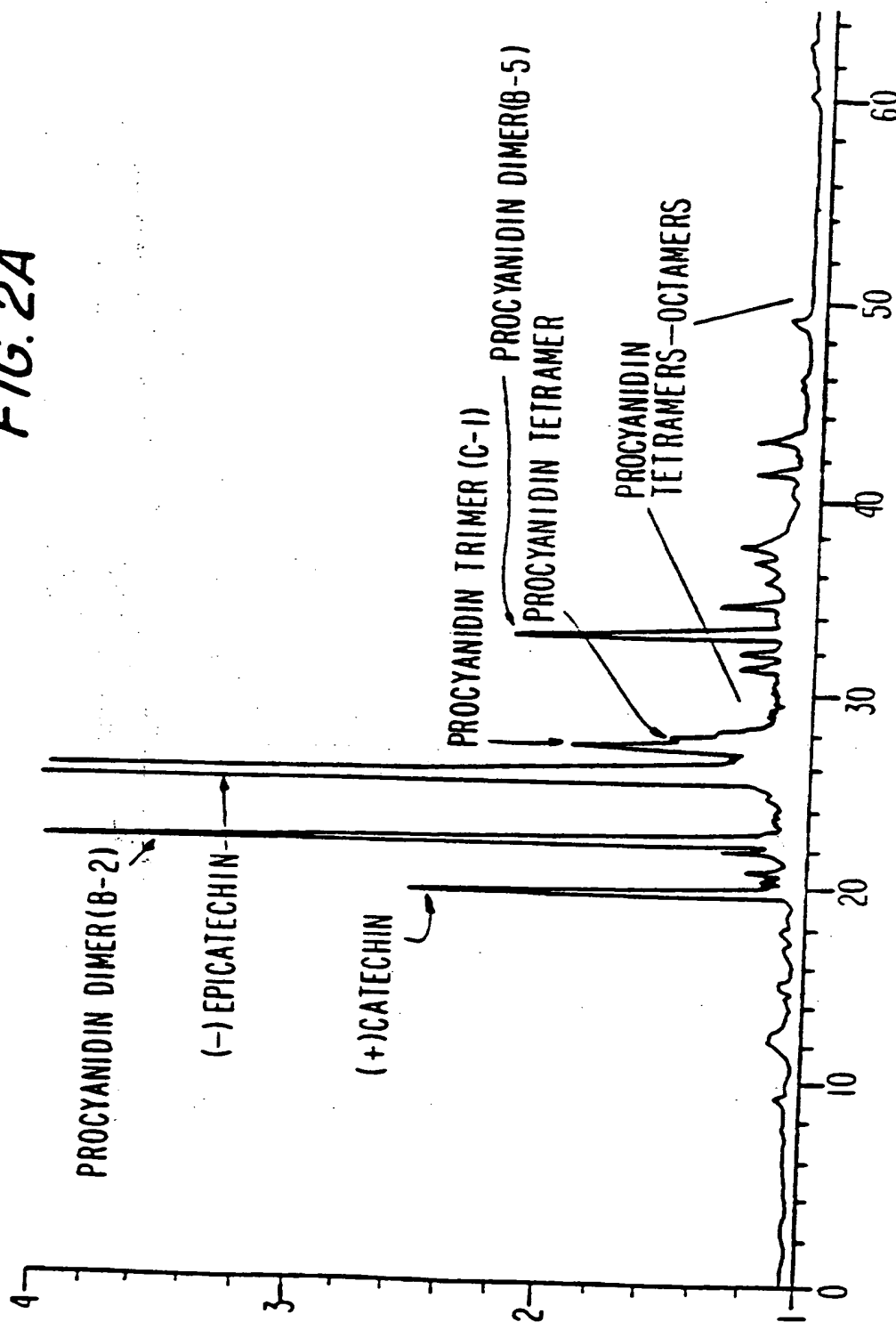
FIG. 1



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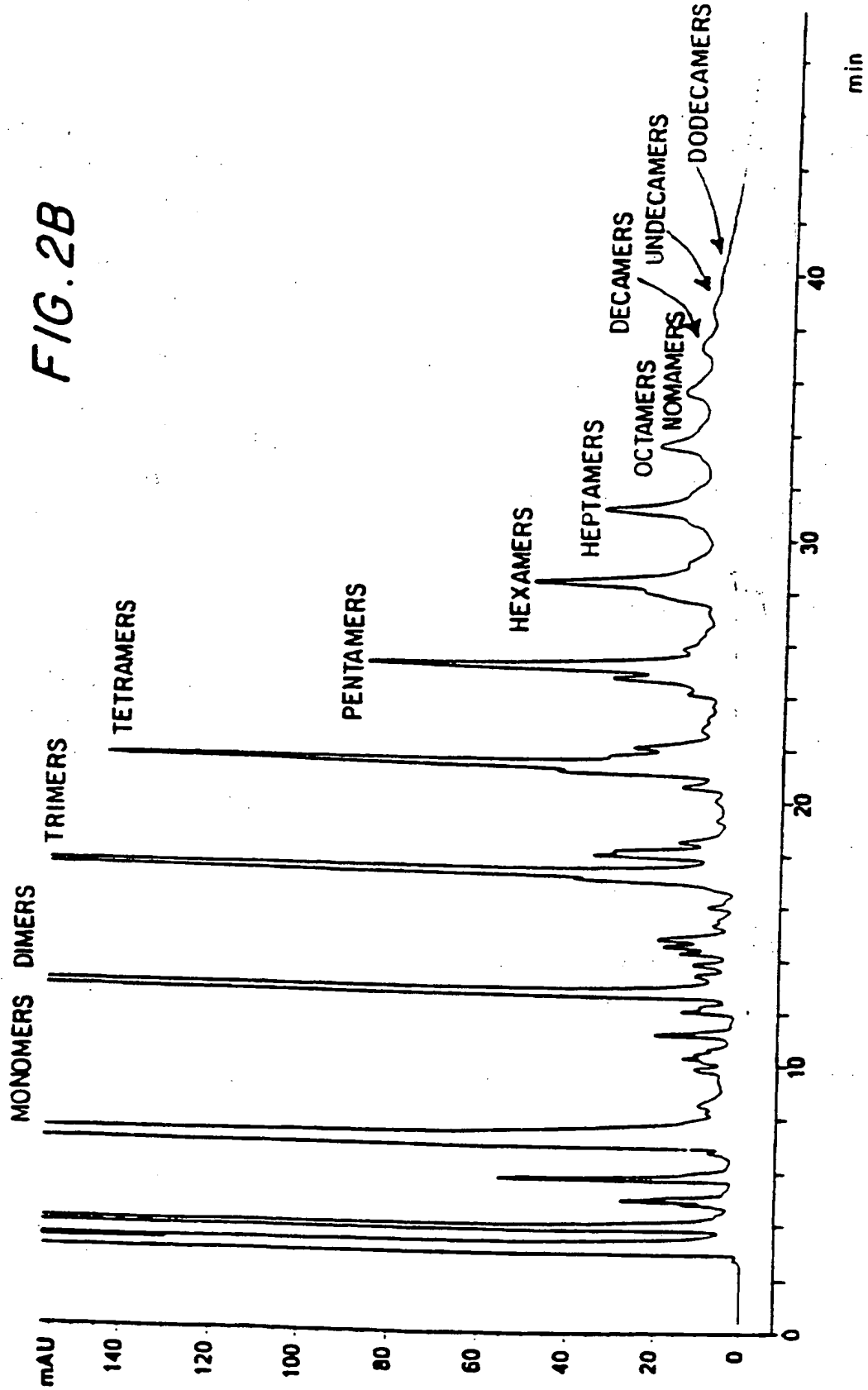
FIG. 2A





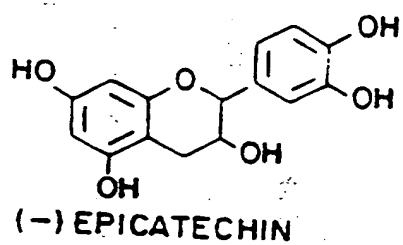
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PROCYANIDIN B-5

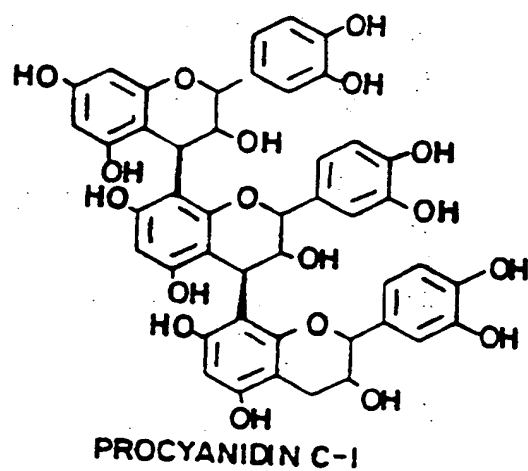
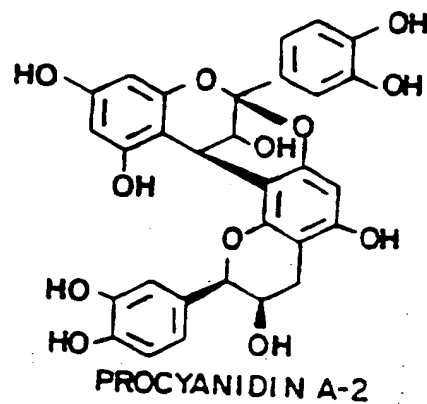
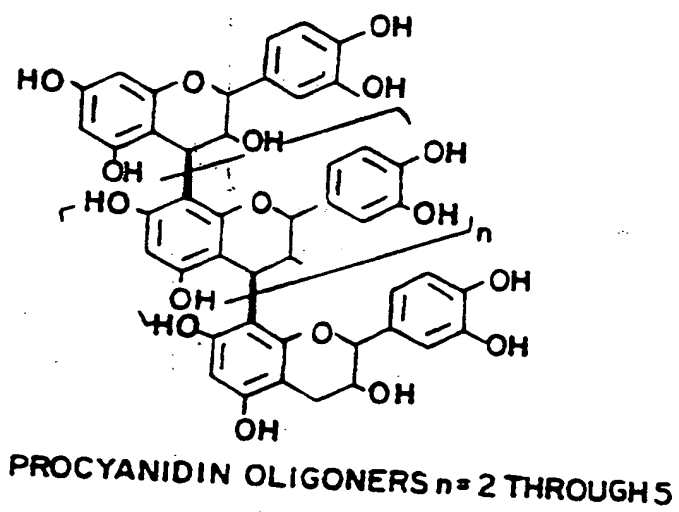
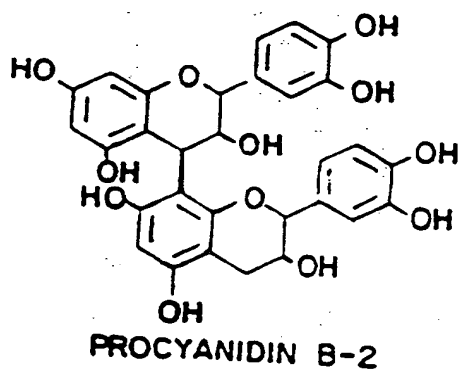
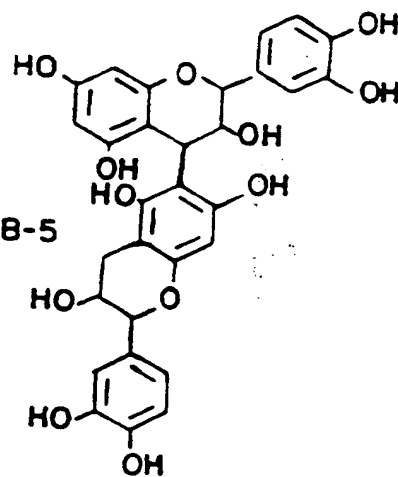
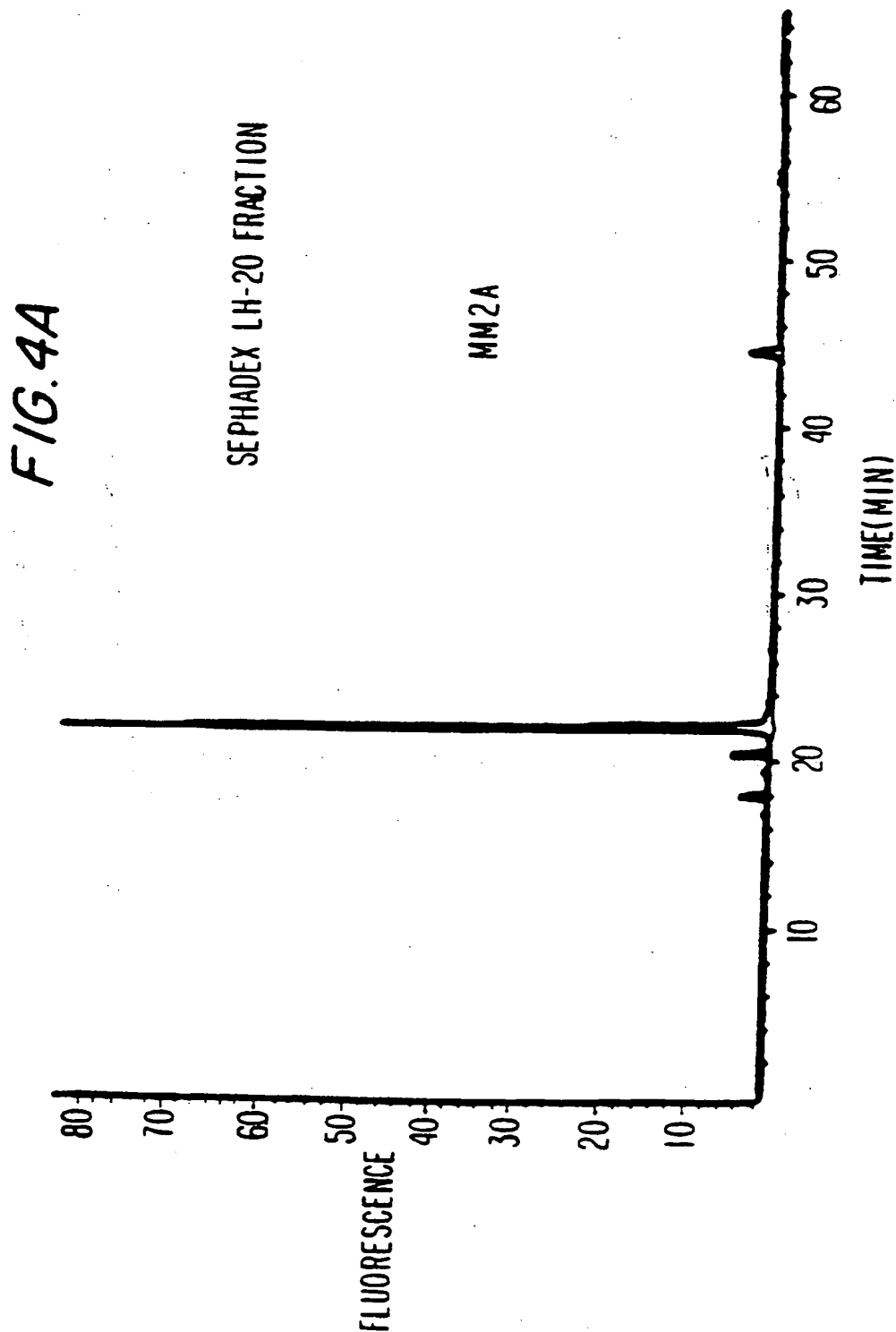


FIG. 3

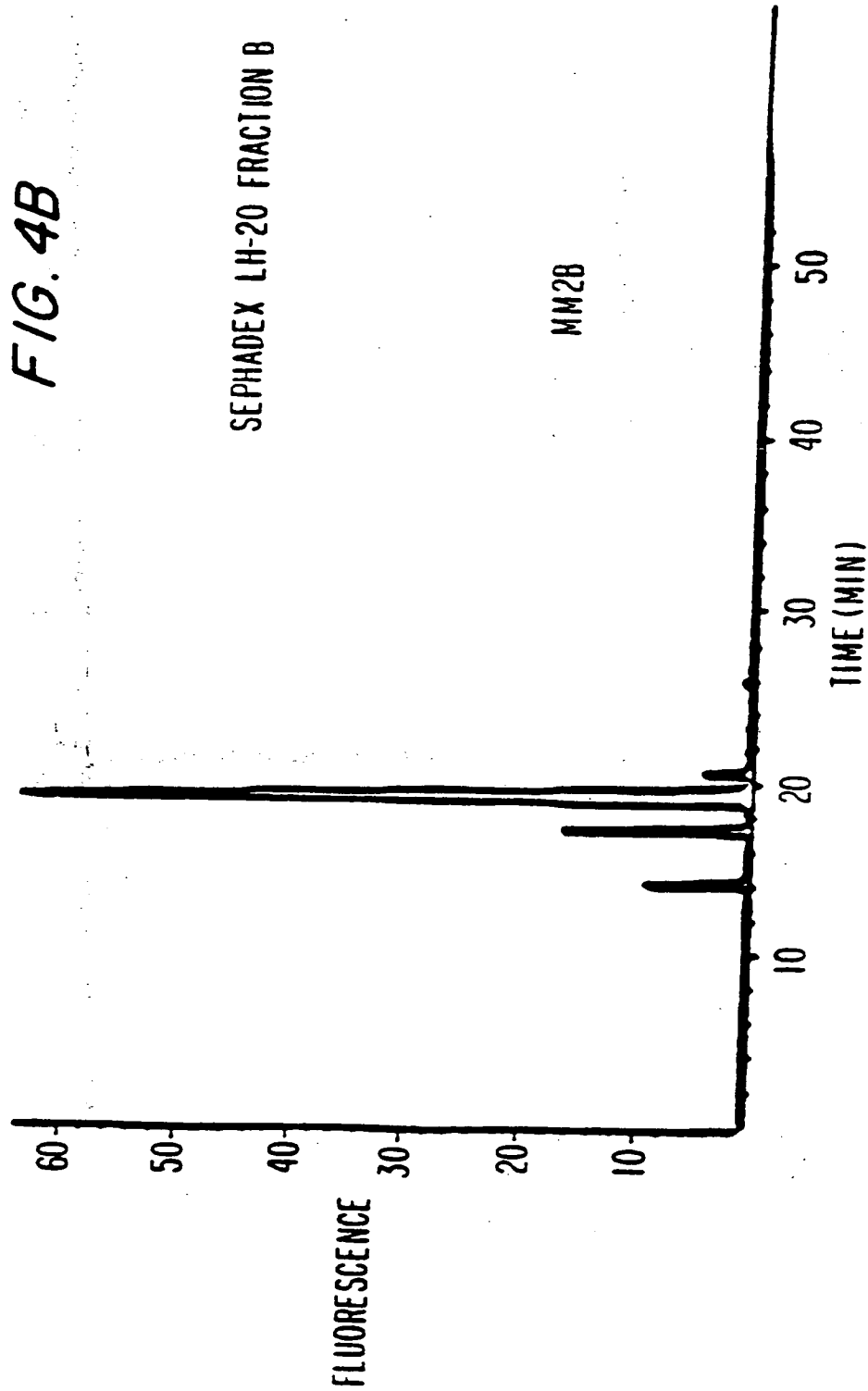
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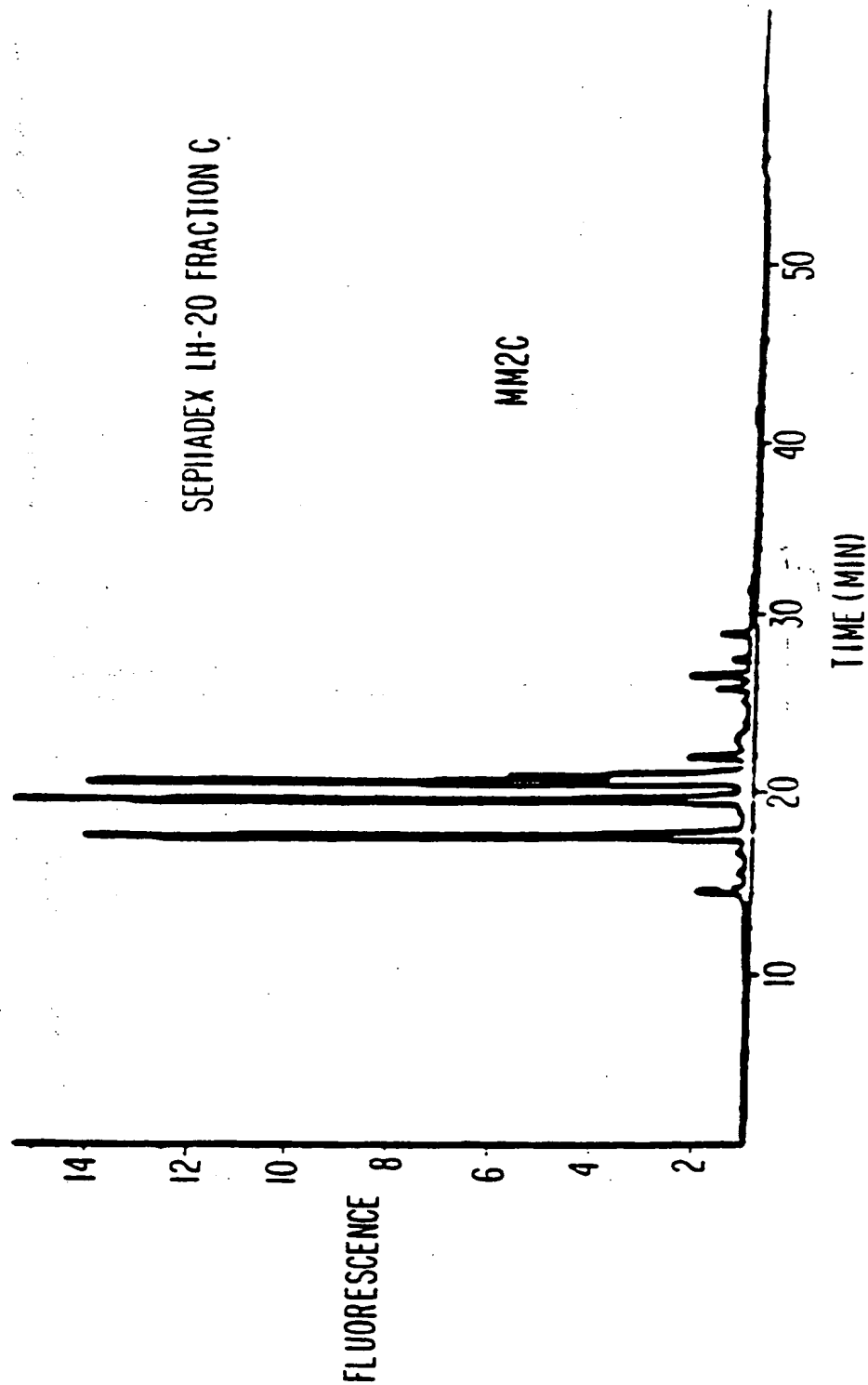
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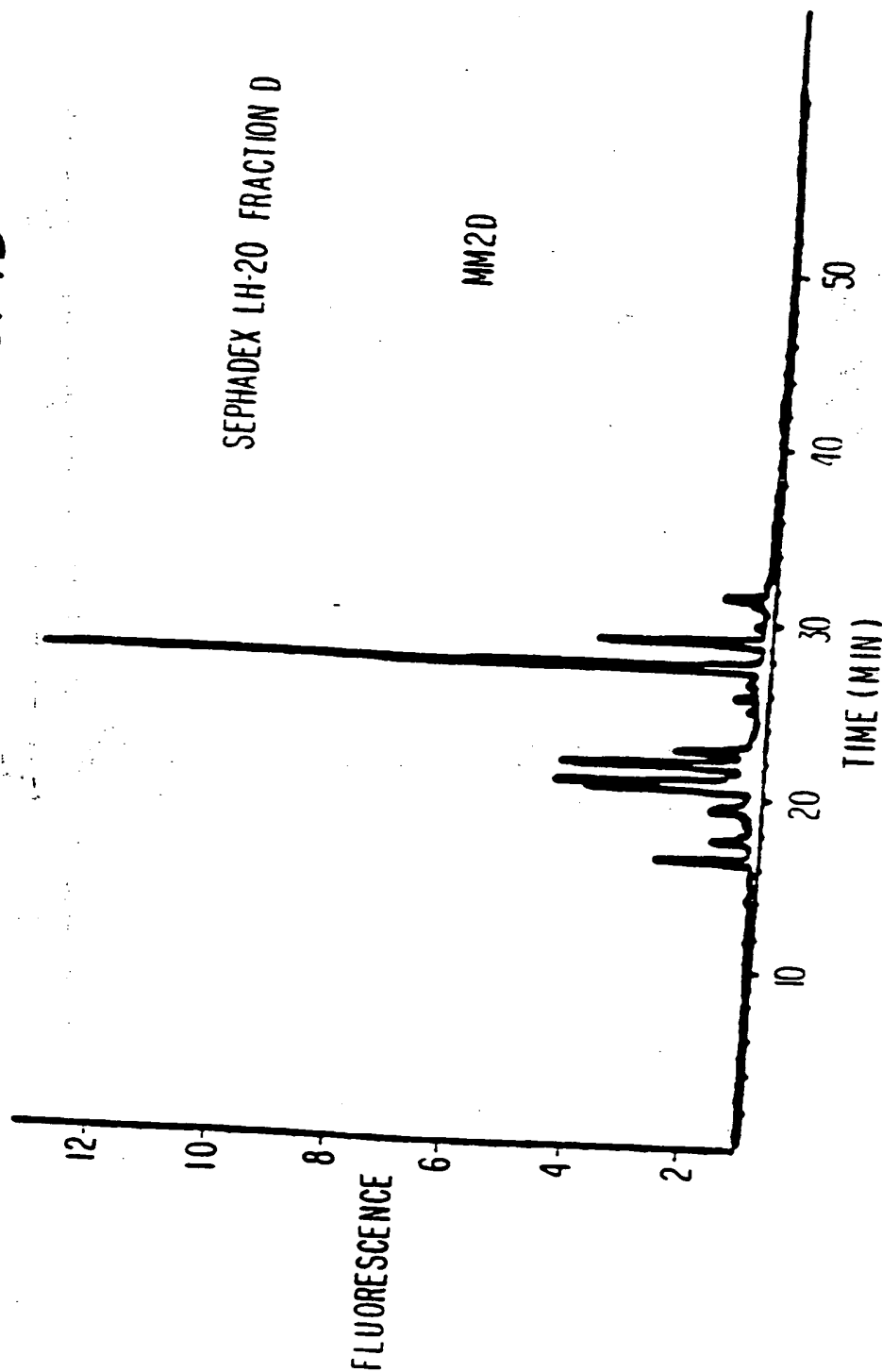
FIG. 4C



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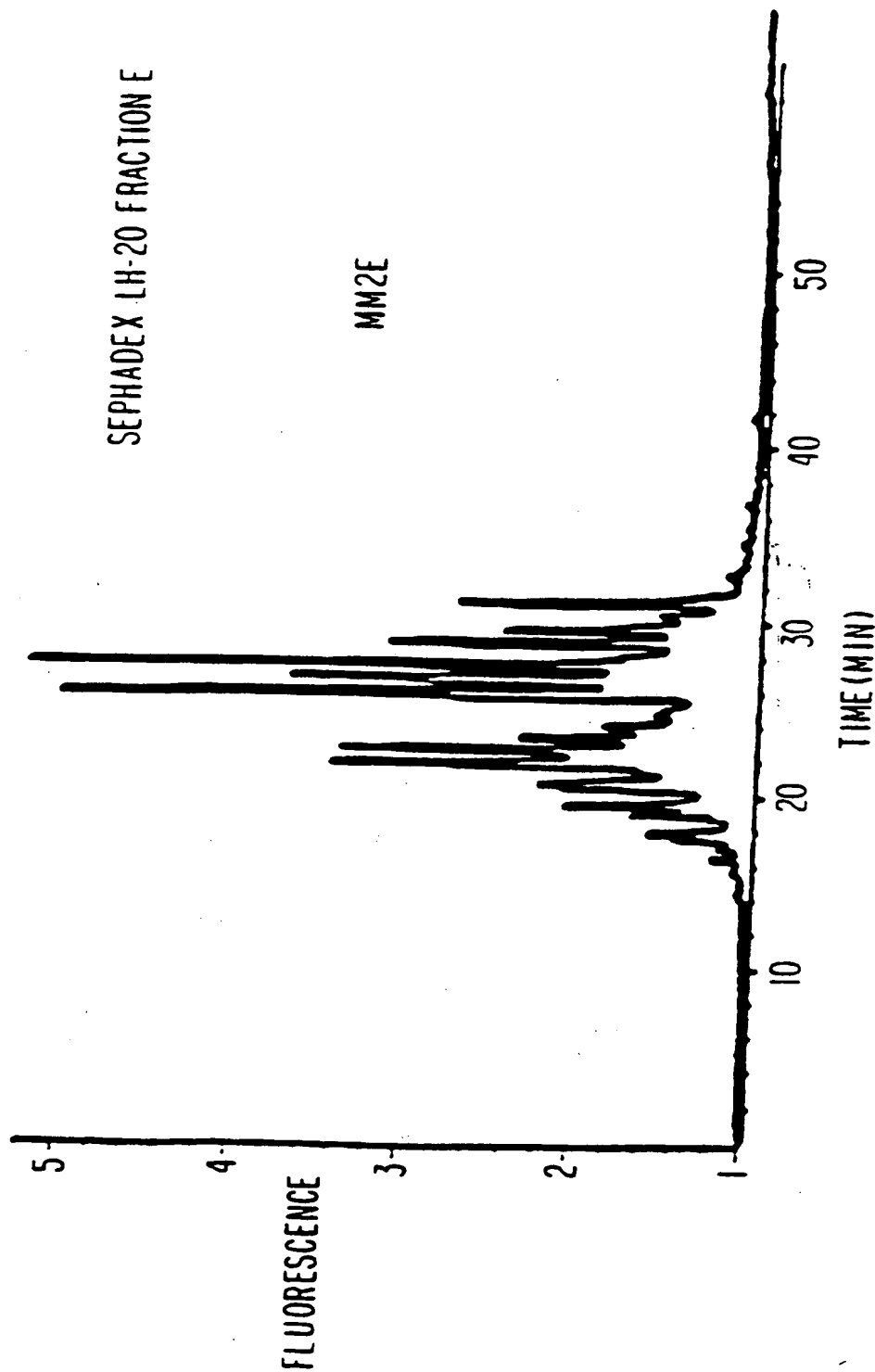
FIG. 4D



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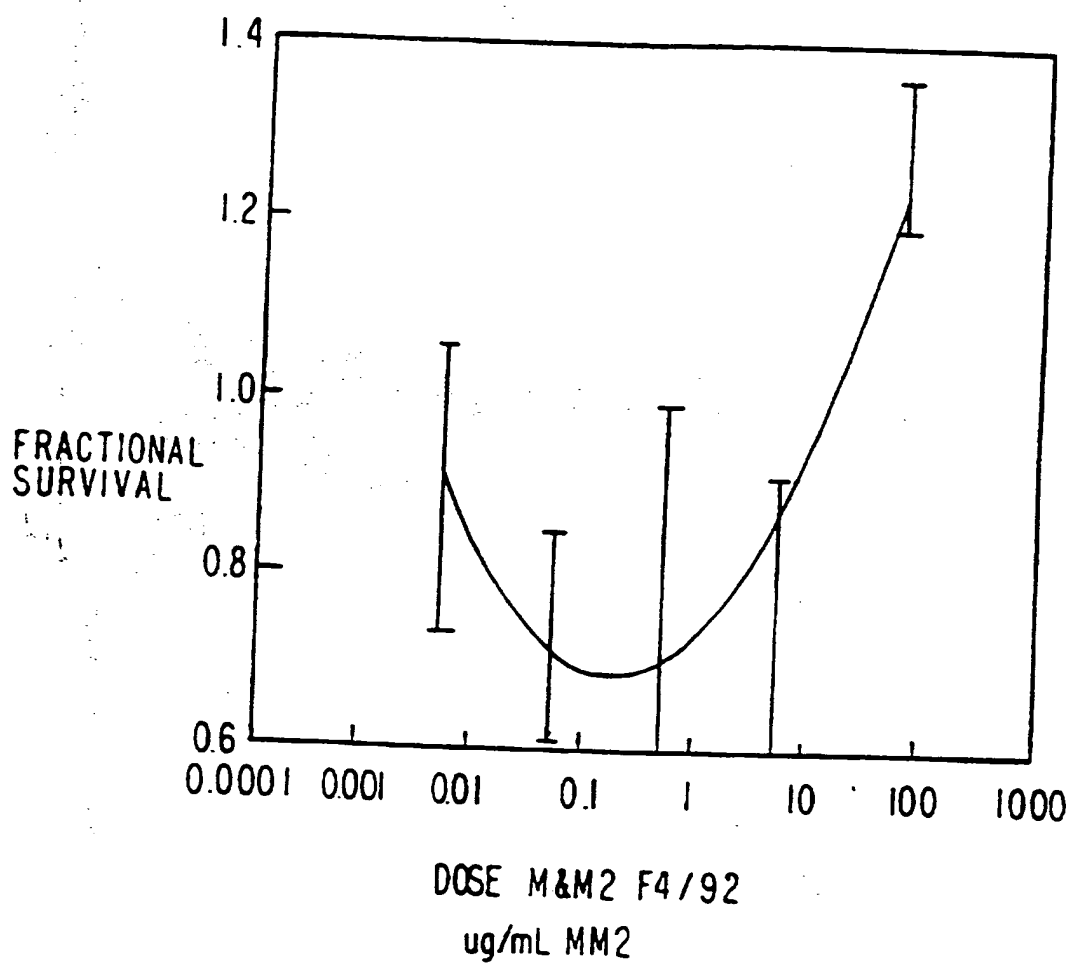
FIG. 4E



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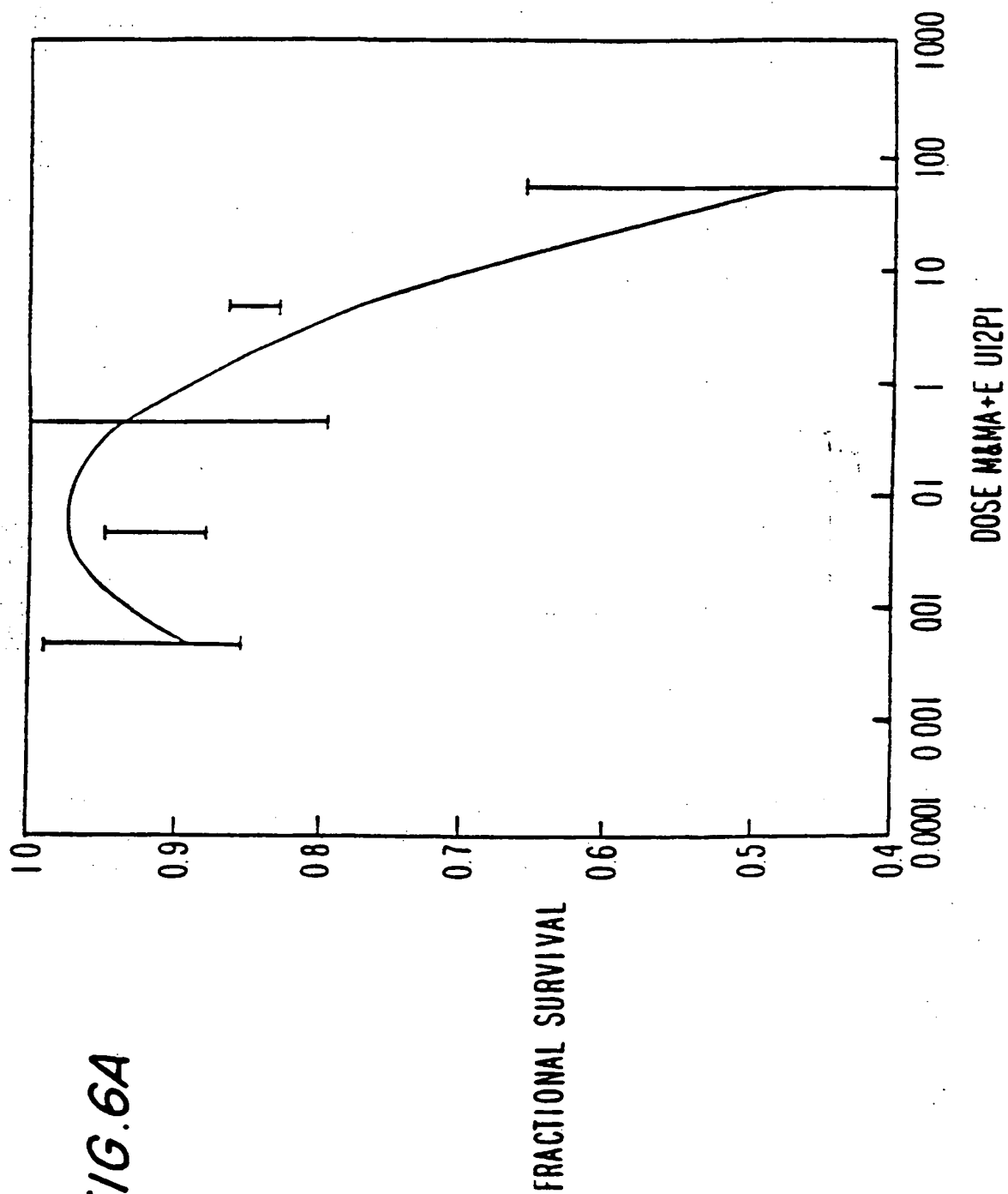
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FIG. 5



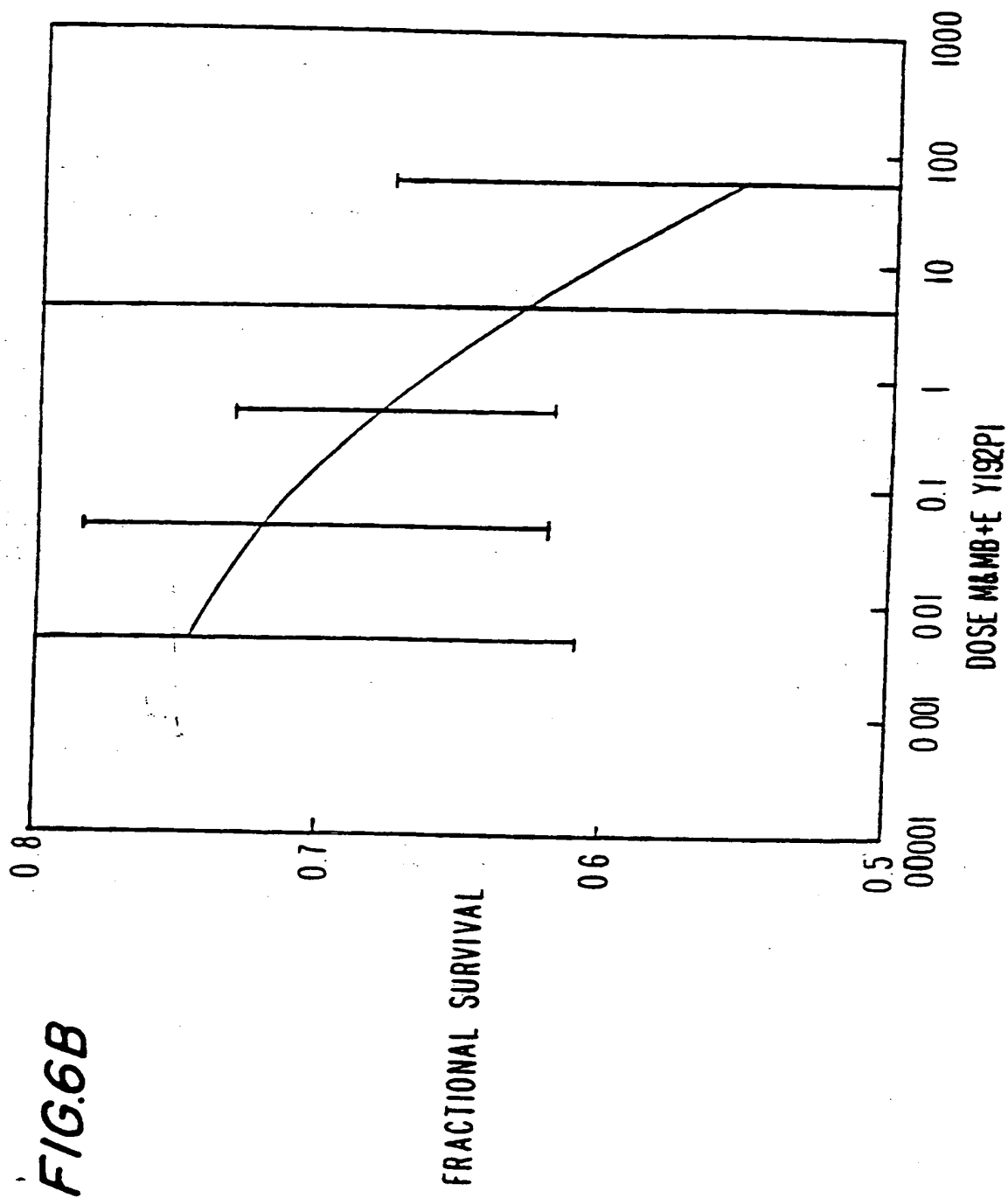


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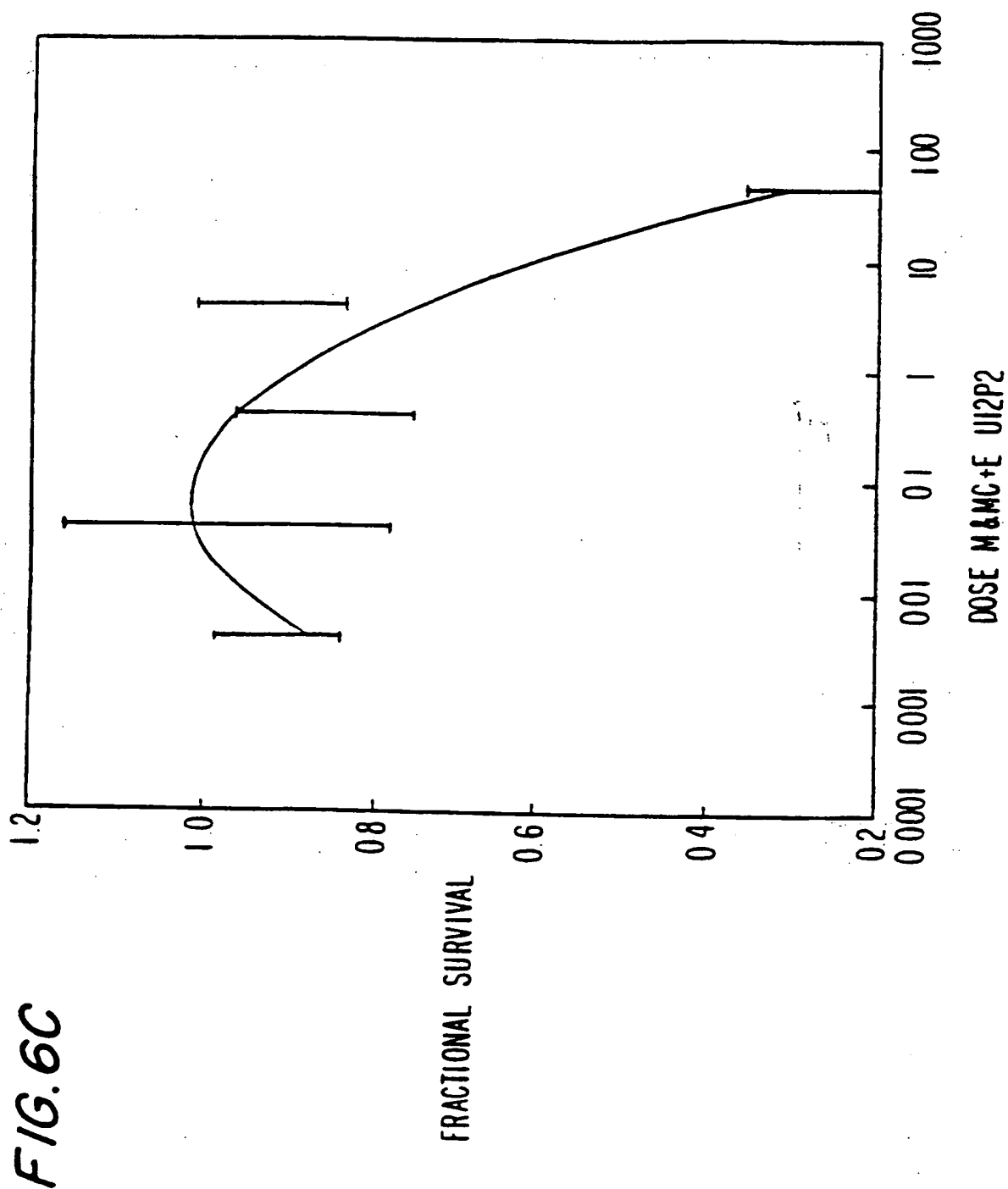


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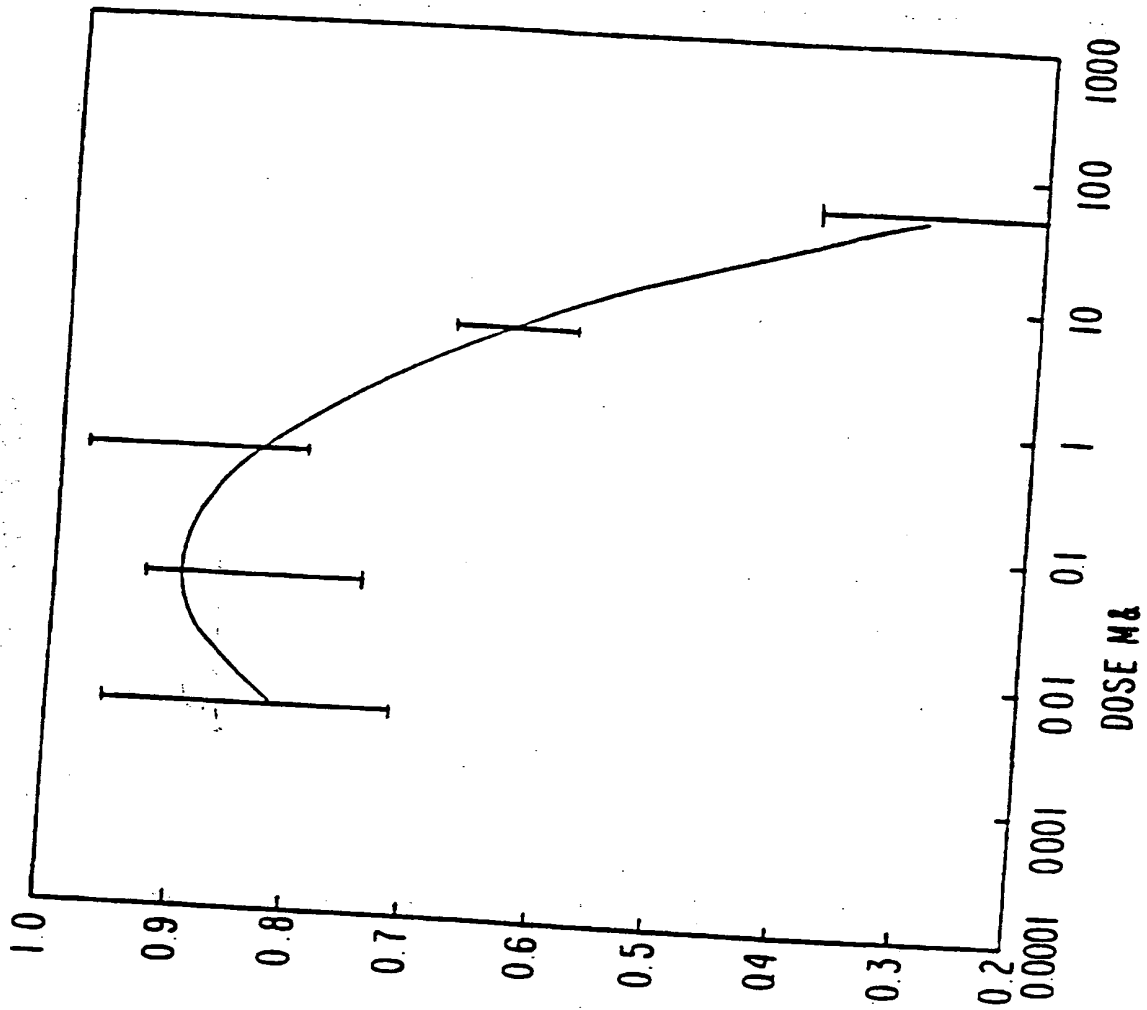
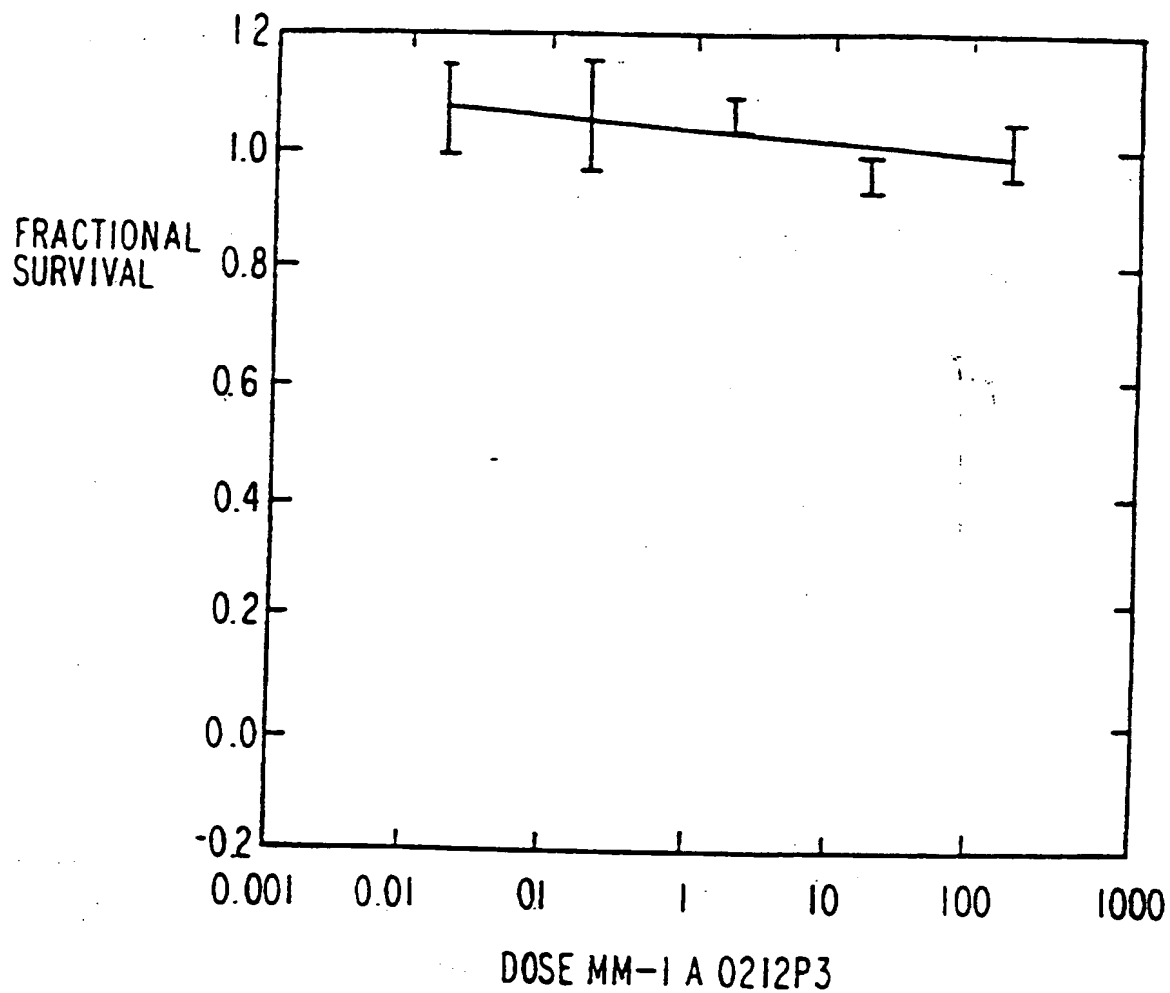


FIG. 6D

FRACTIONAL  
SURVIVAL

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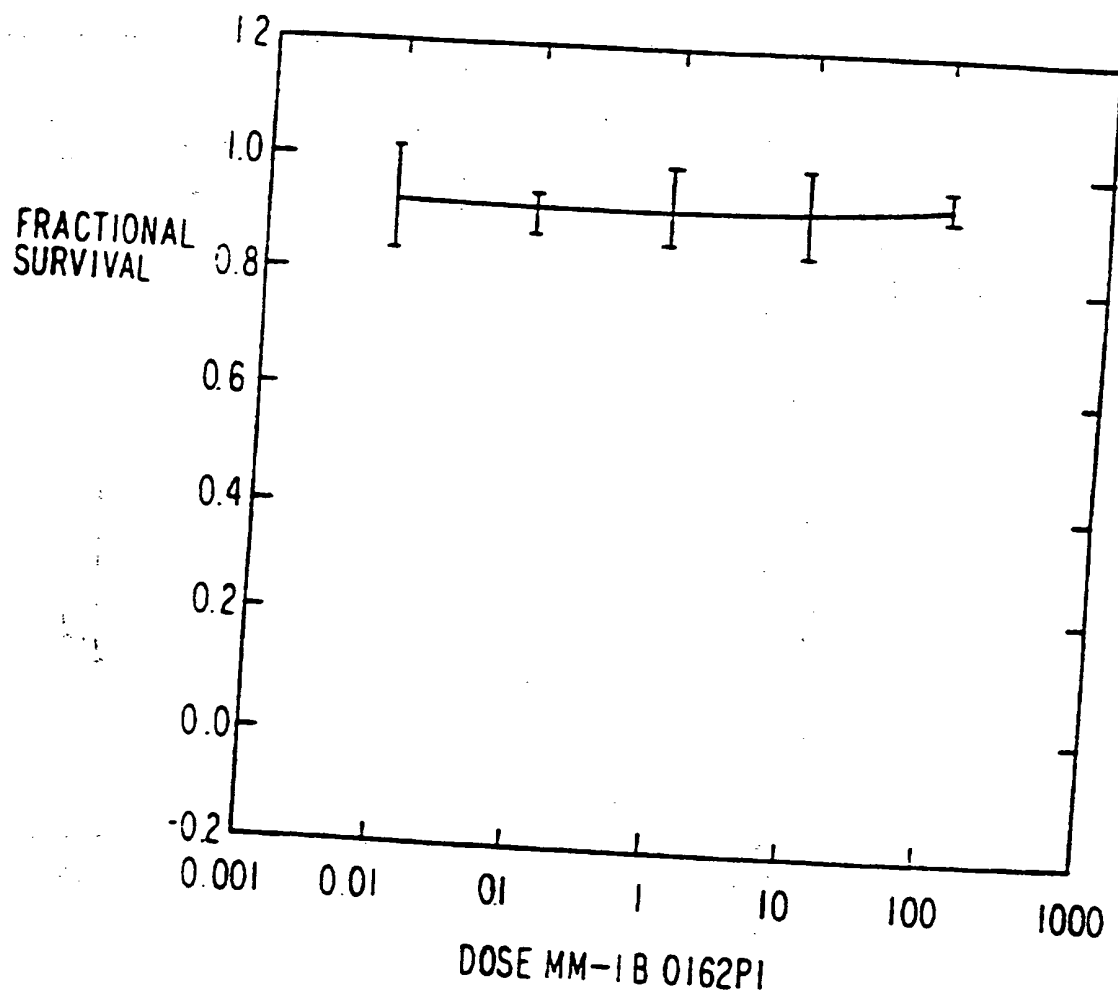
FIG. 7A



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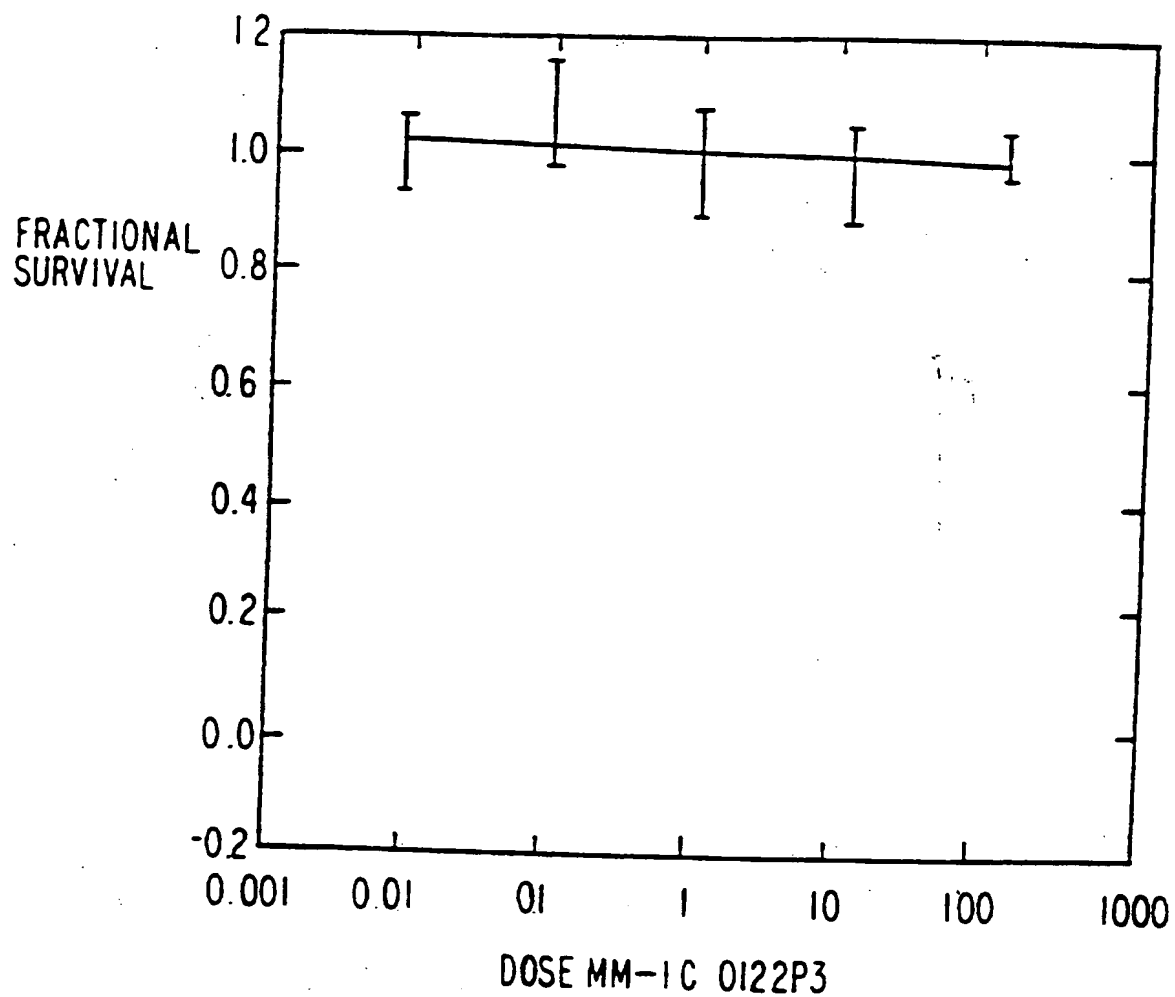
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FIG. 7B



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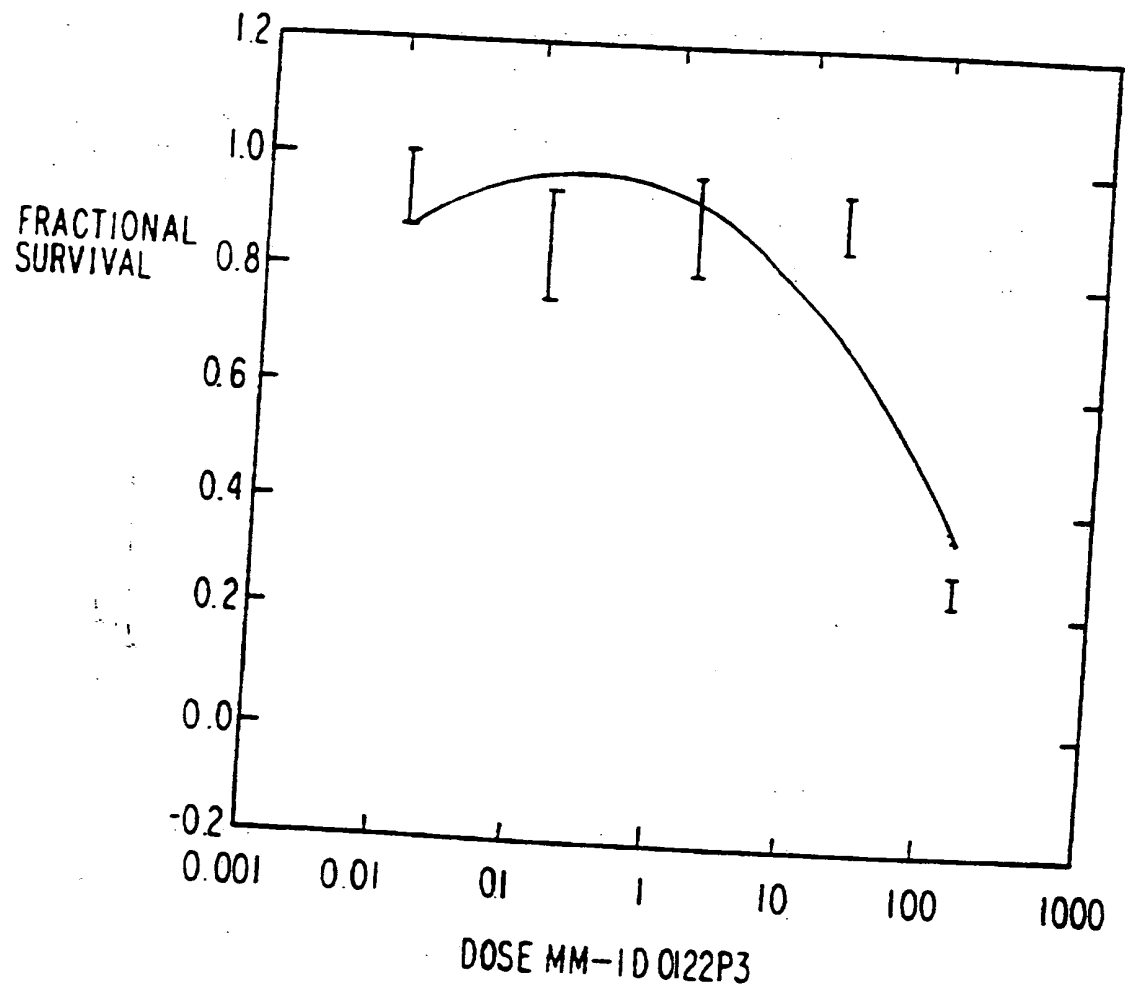
FIG. 7C



SUBSTITUTE SHEET (RULE 26)

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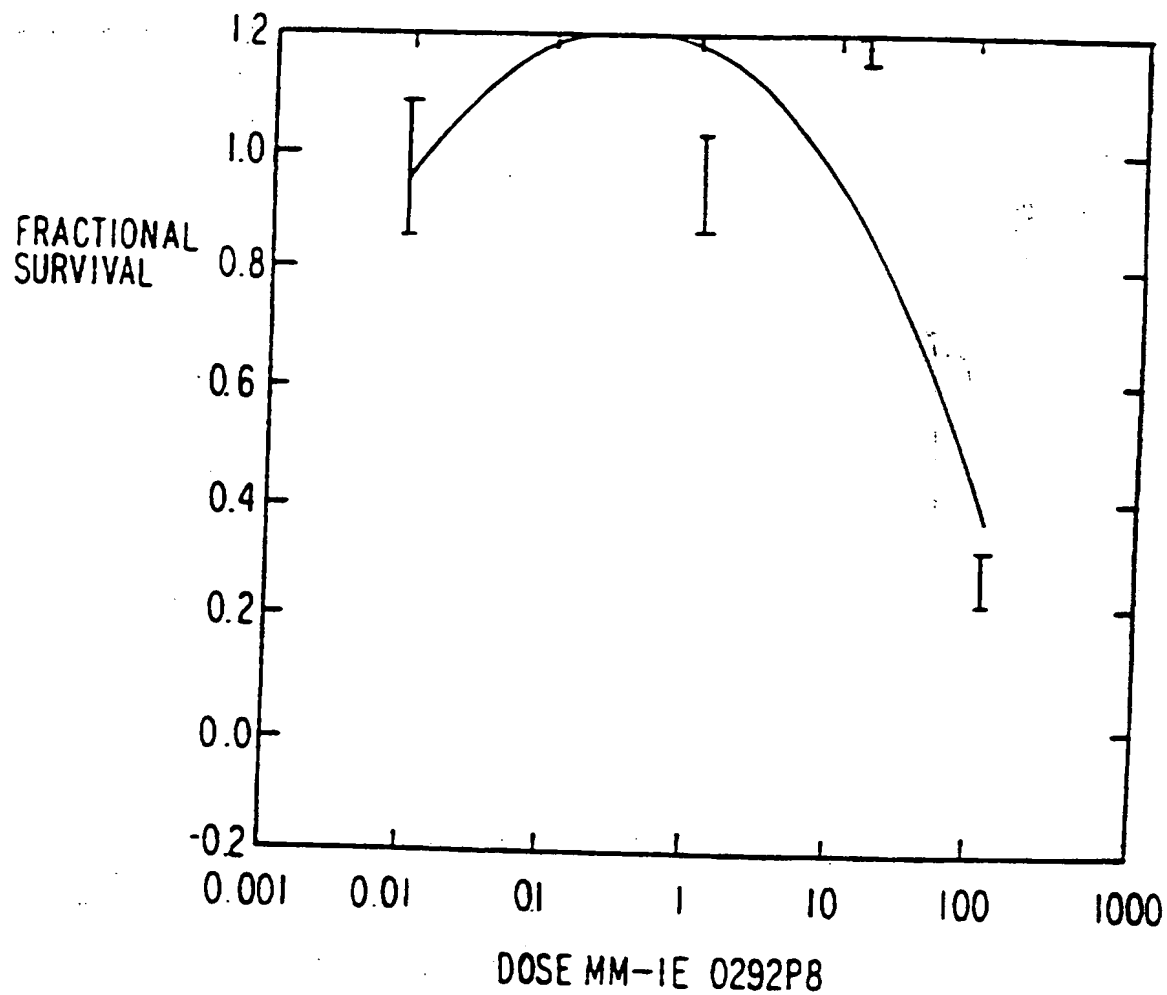
FIG. 7D





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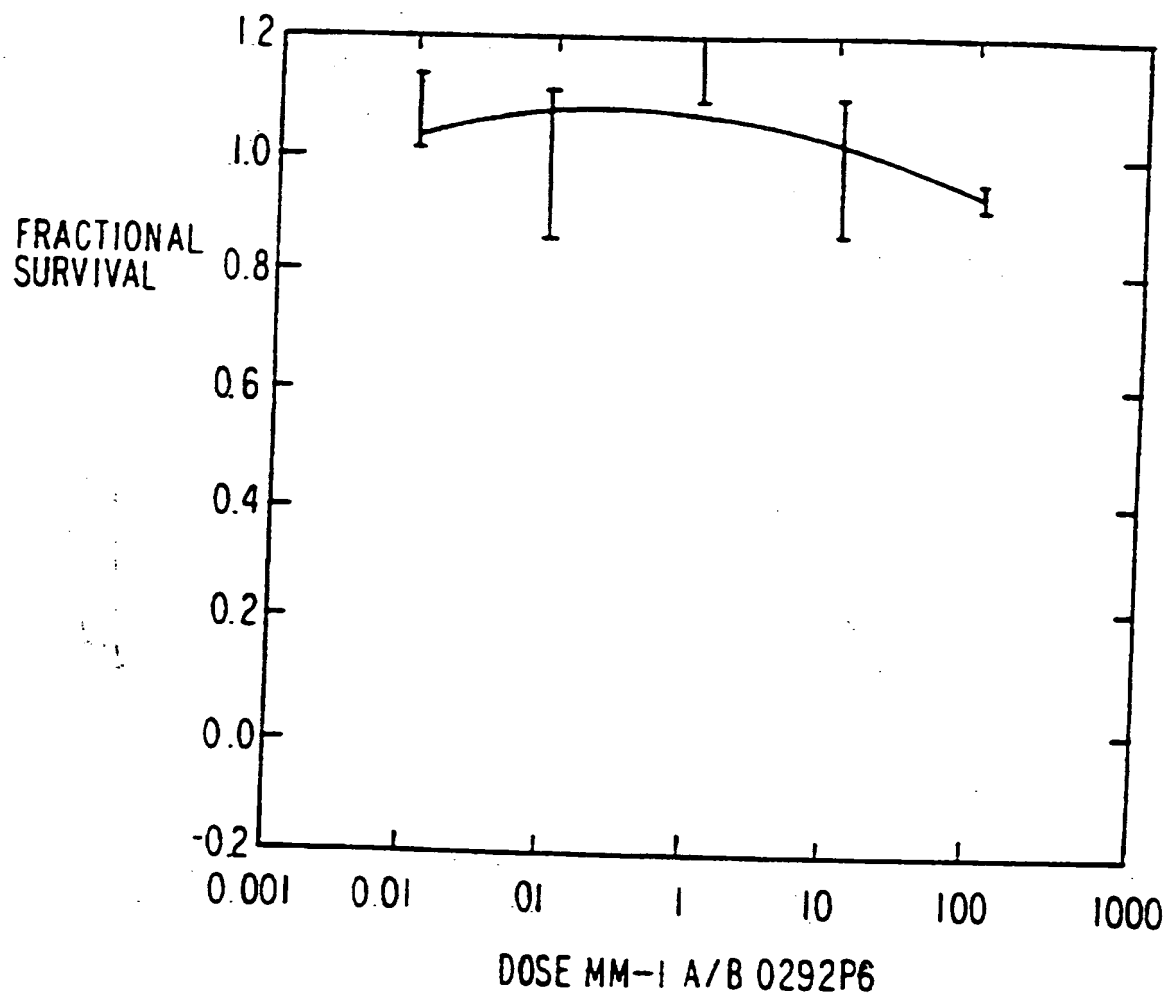
FIG. 7E



SUBSTITUTE SHEET (RULE 26)

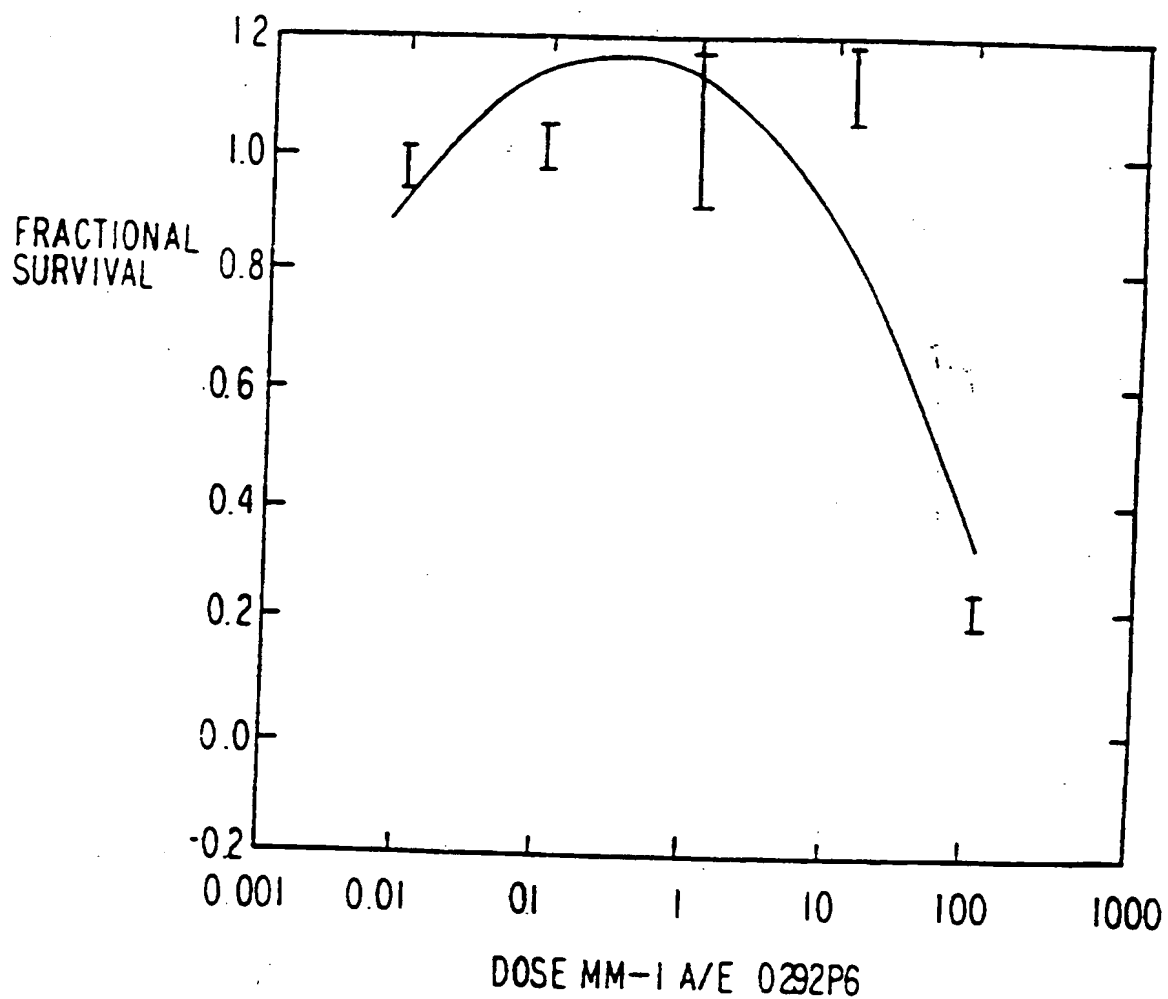
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FIG. 7F



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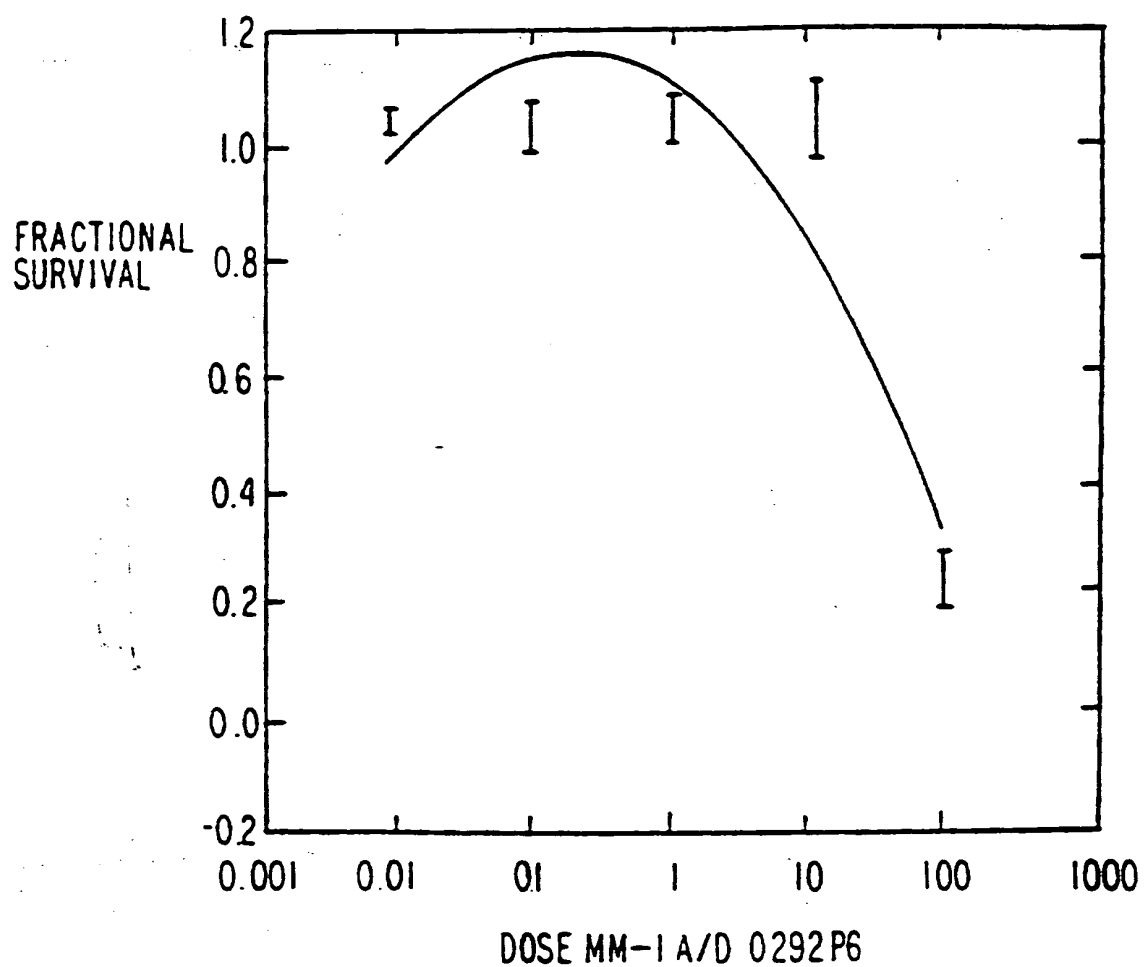
FIG. 7G



SUBSTITUTE SHEET (RULE 26)

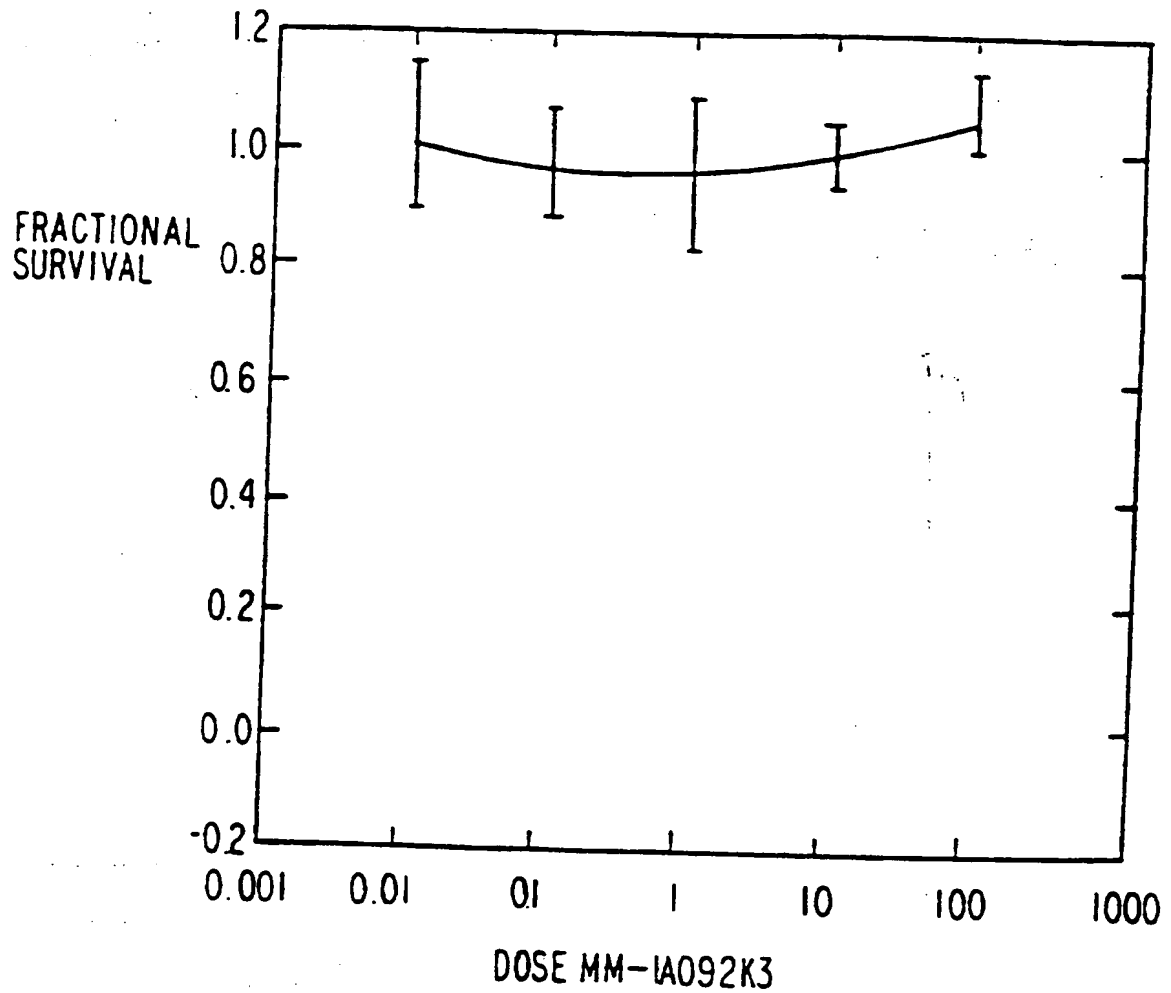
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FIG. 7H



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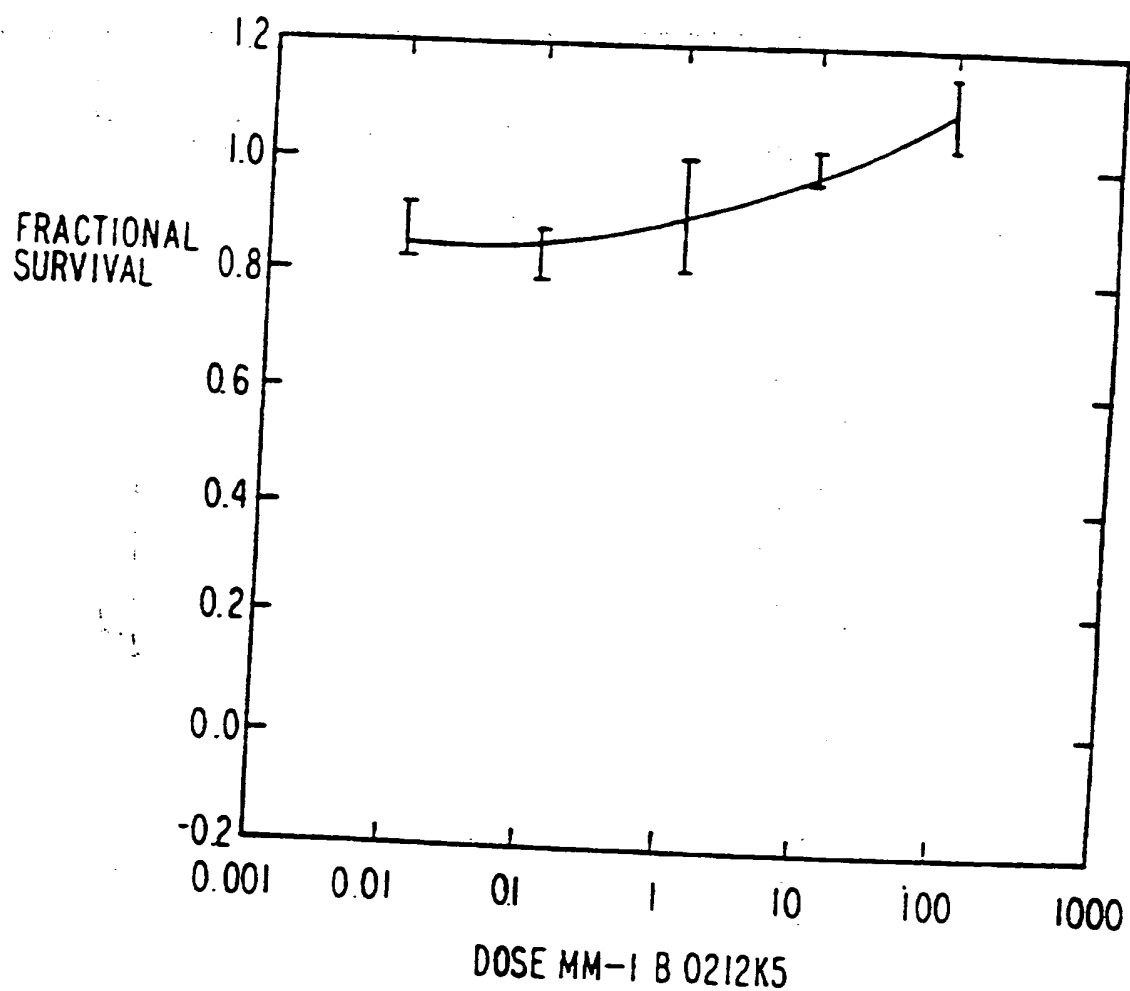
FIG. 8A



SUBSTITUTE SHEET (RULE 26)

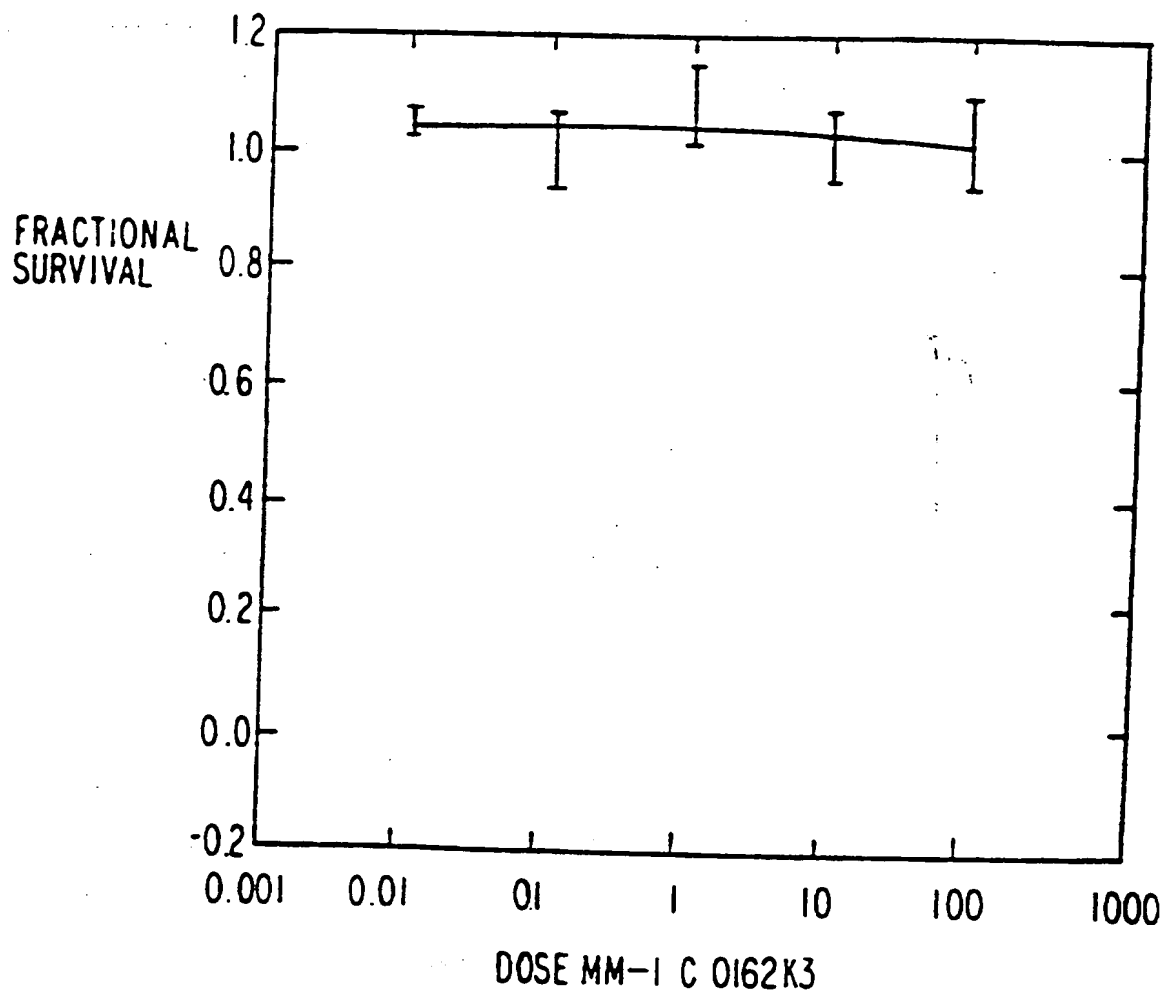
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FIG. 8B



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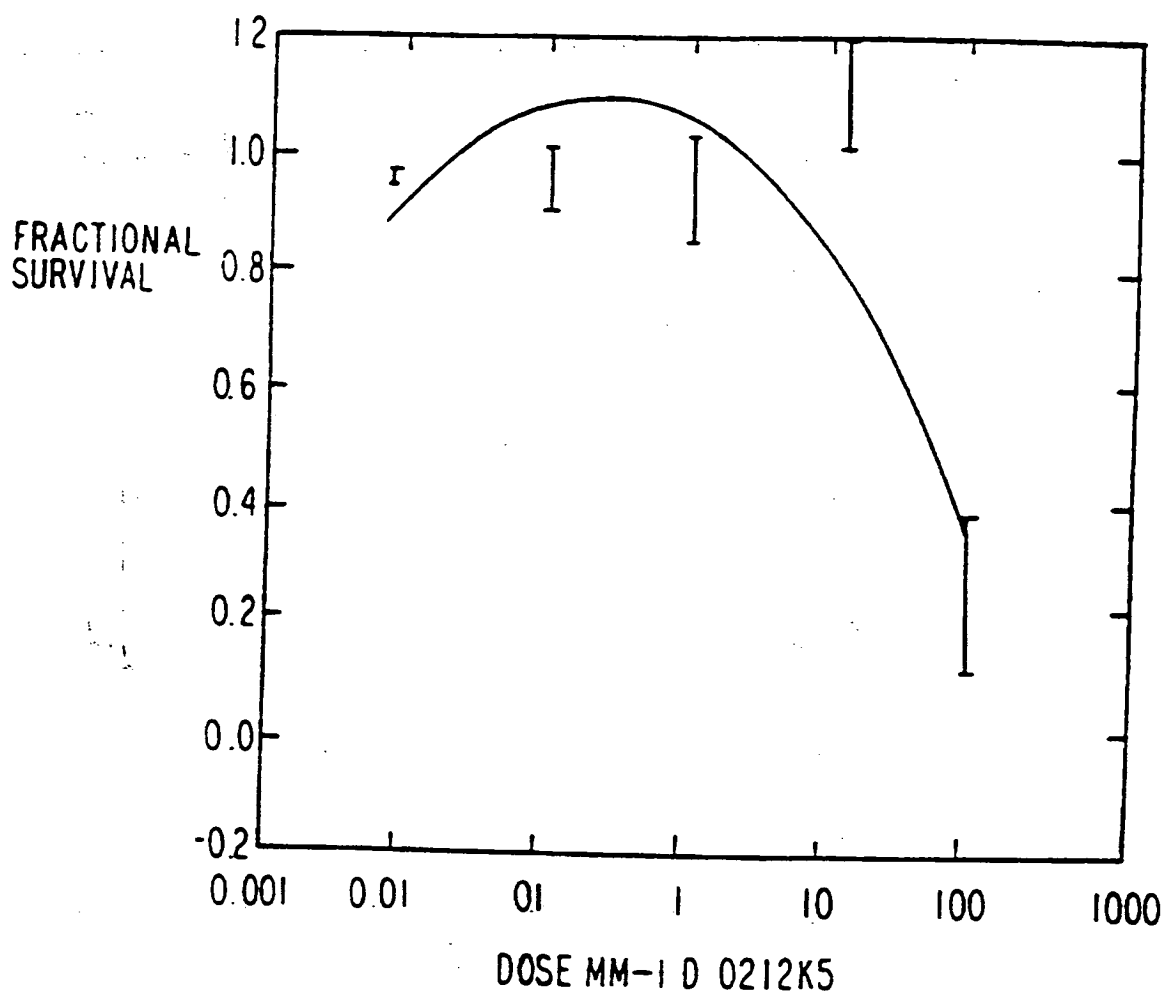
FIG. 8C



SUBSTITUTE SHEET (RULE 26)

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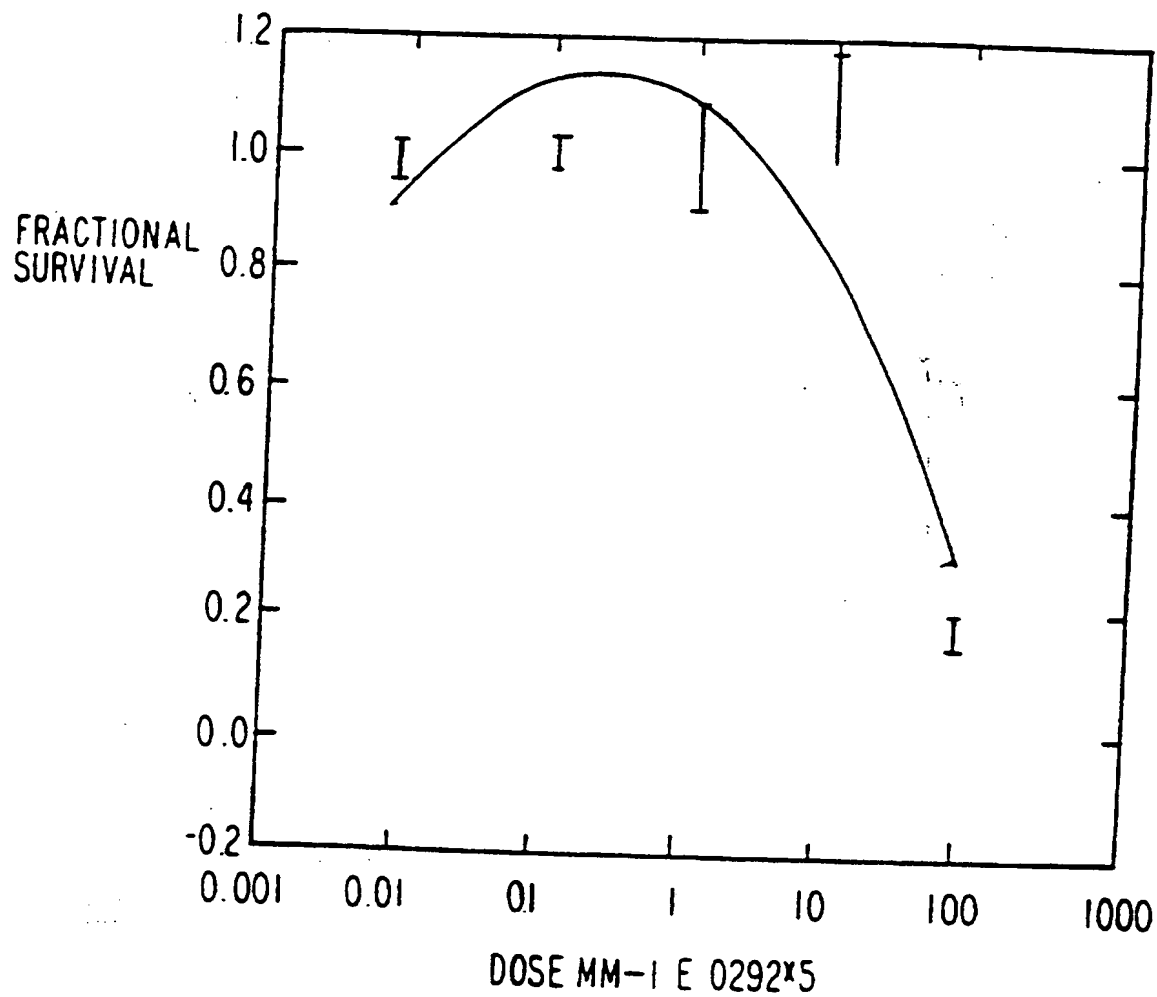
FIG. 8D





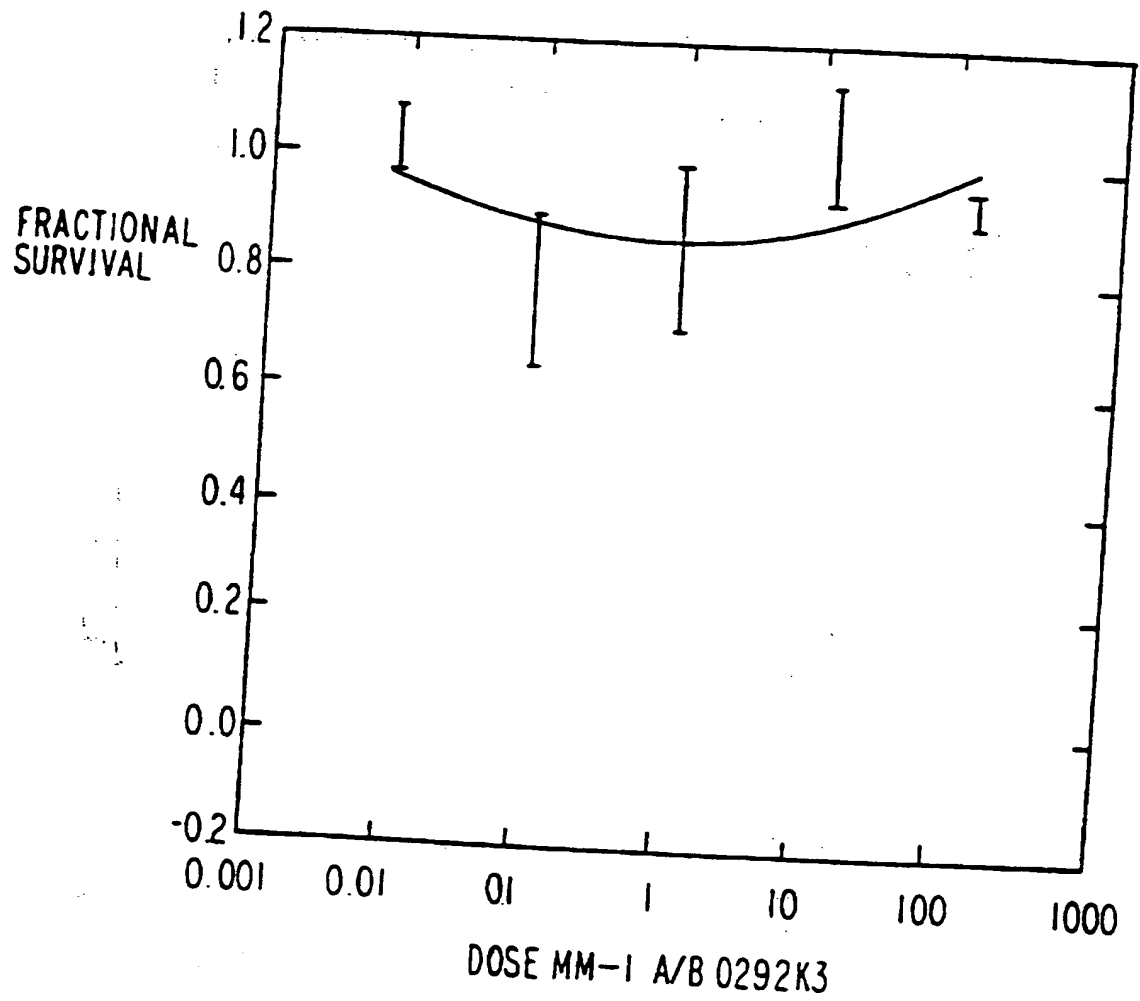
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FIG. 8E



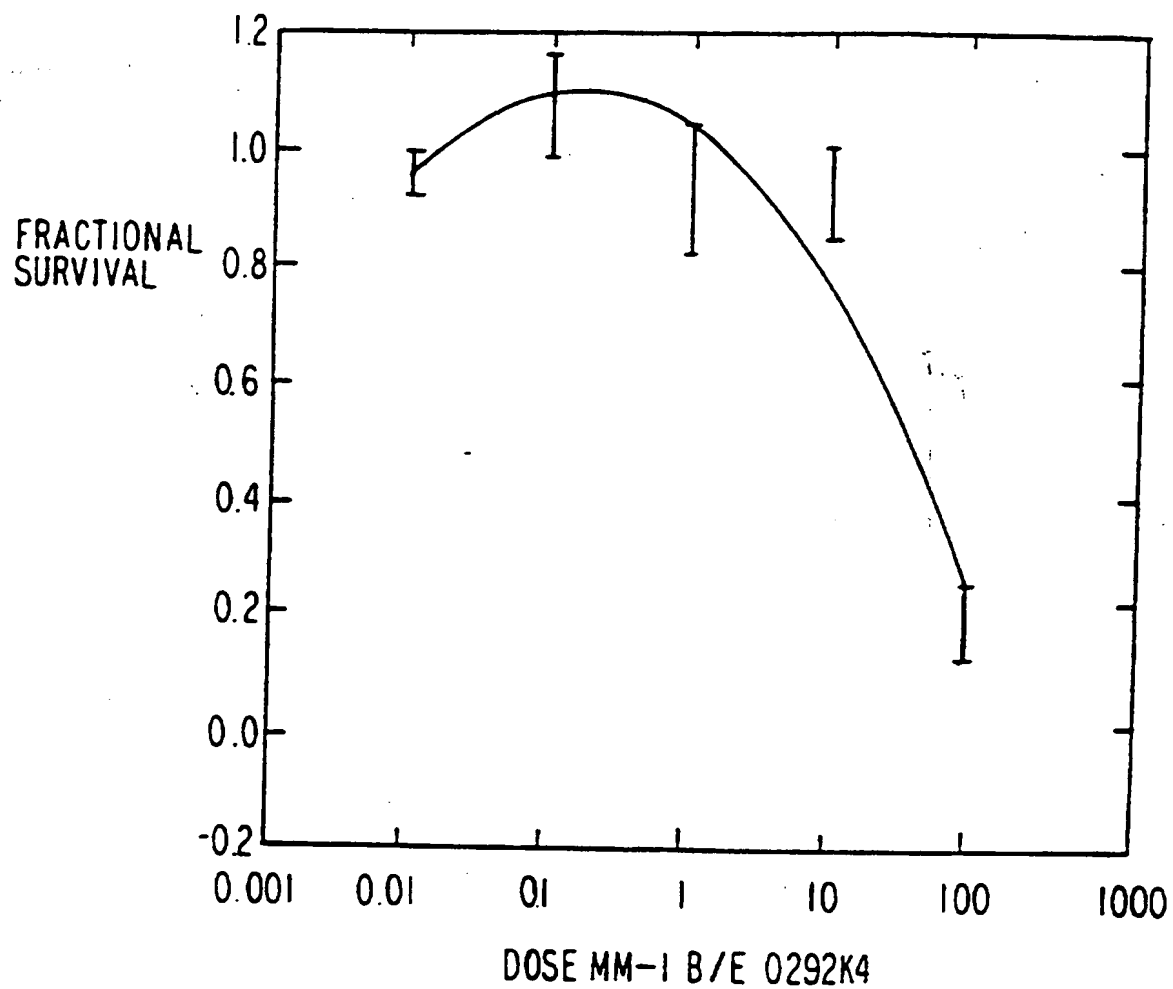
SUBSTITUTE SHEET (RULE 26)

FIG. 8F



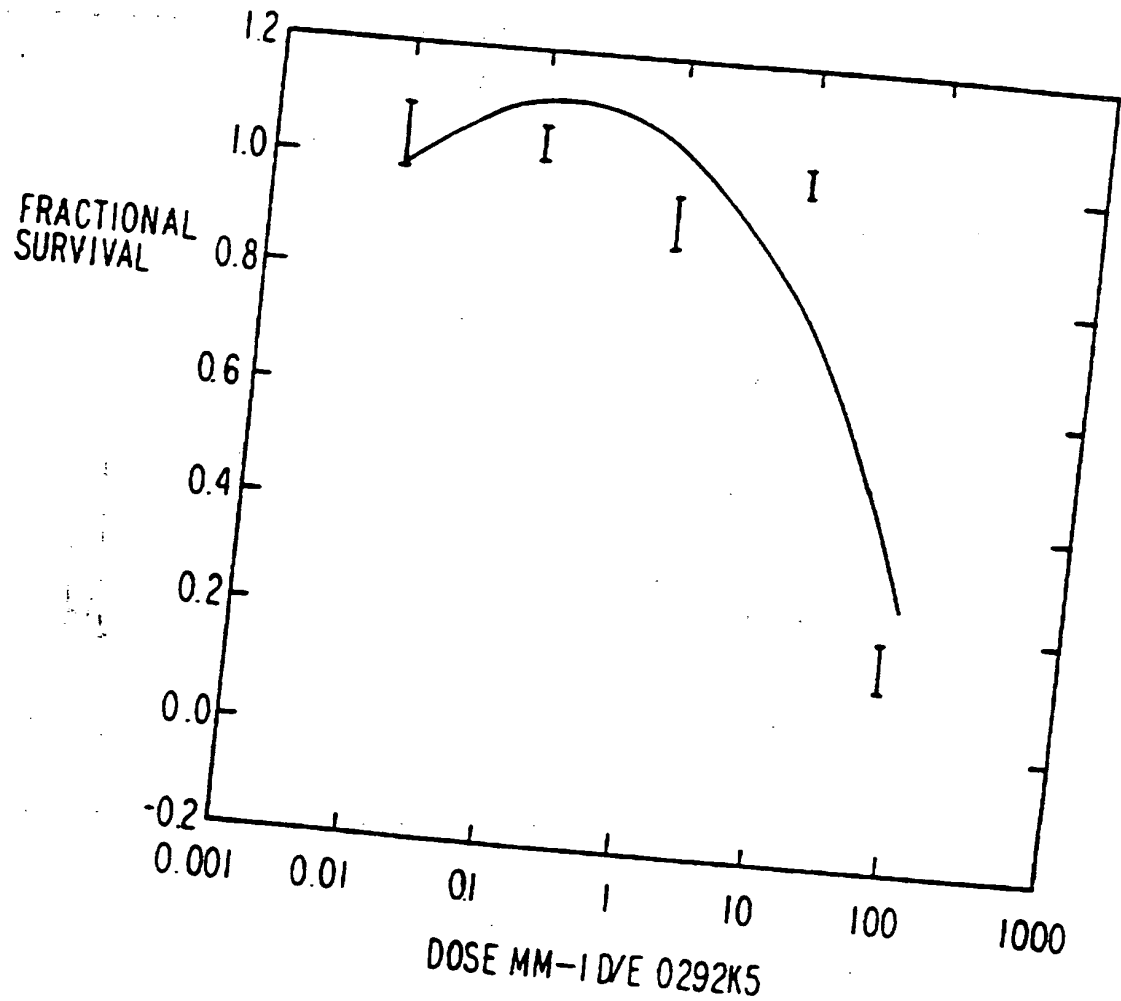
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FIG. 8G



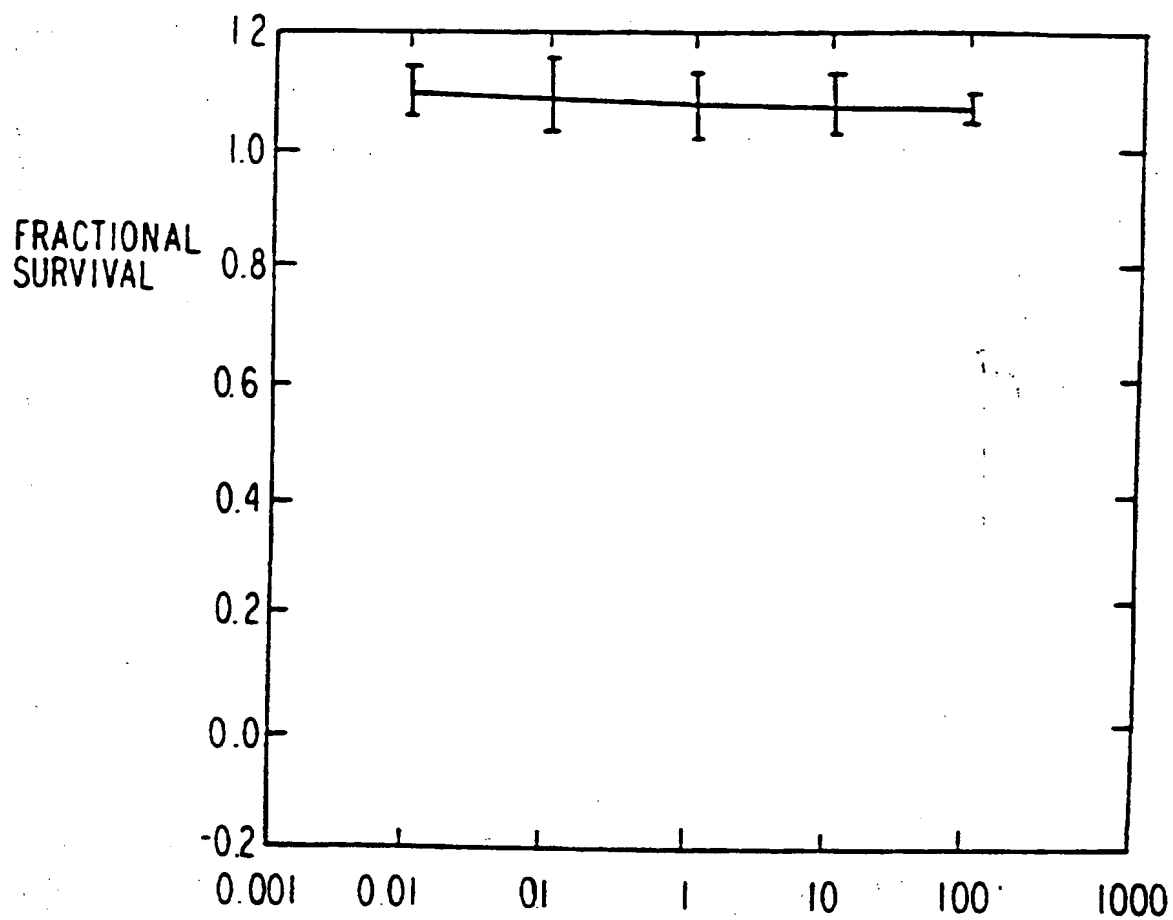
SUBSTITUTE SHEET (RULE 26)

FIG. 8H



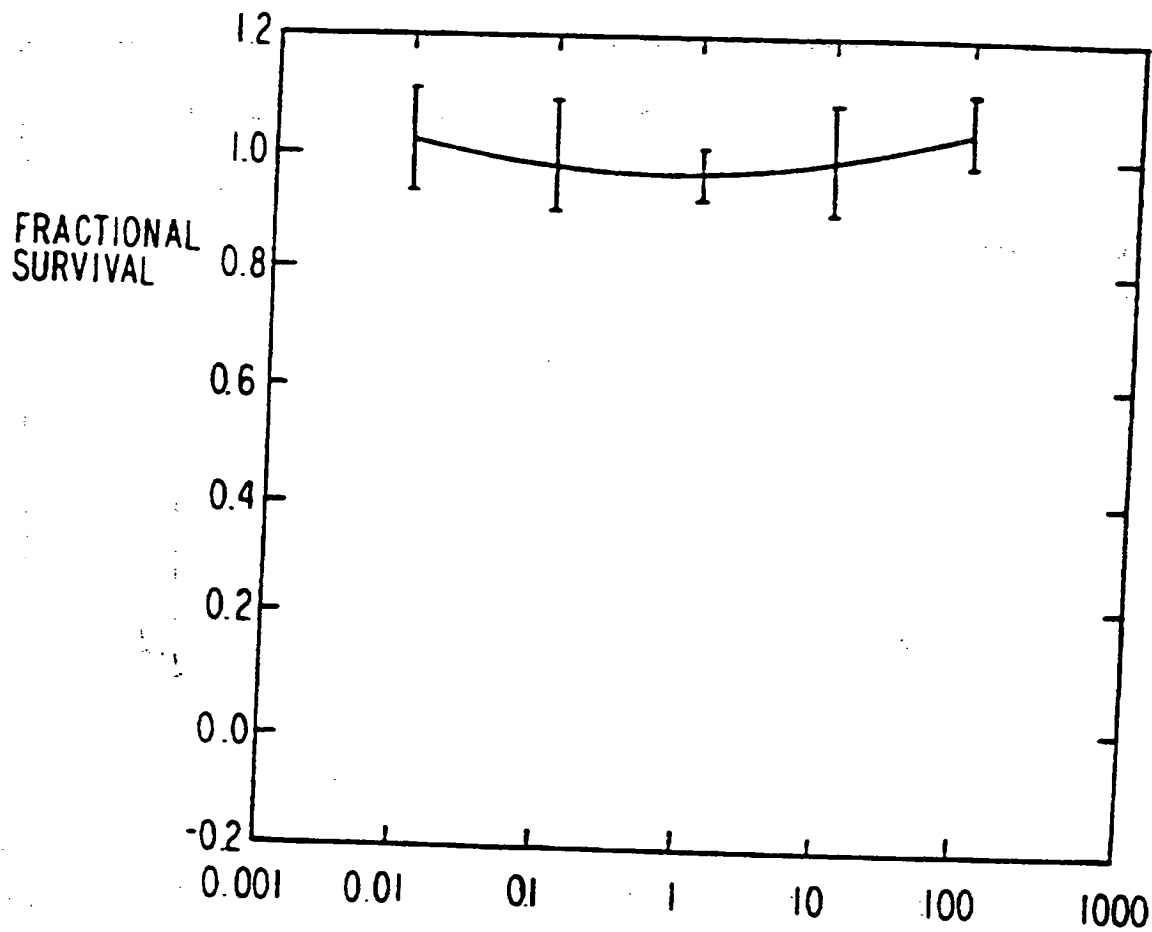
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FIG. 9A



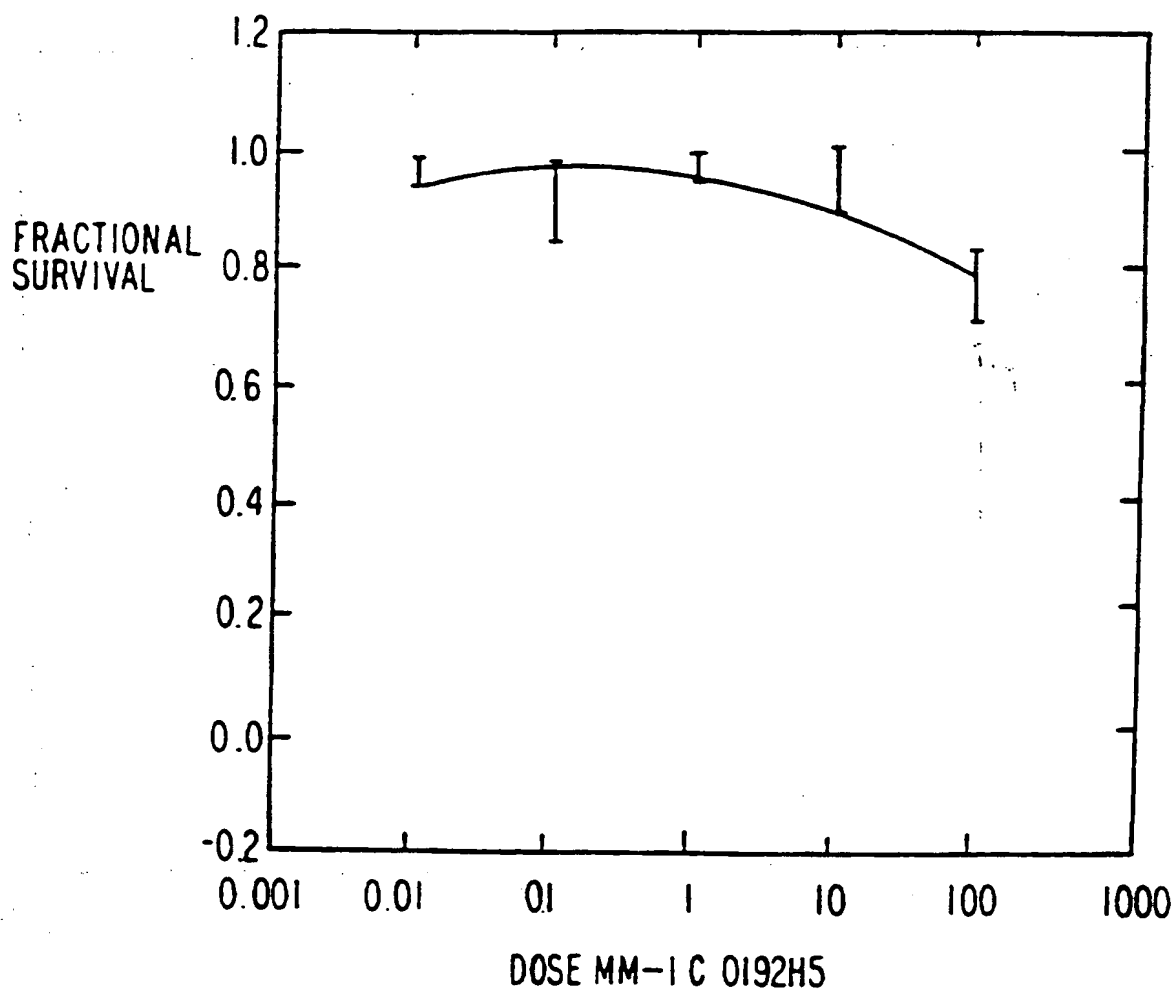
SUBSTITUTE SHEET (RULE 26)

FIG. 9B



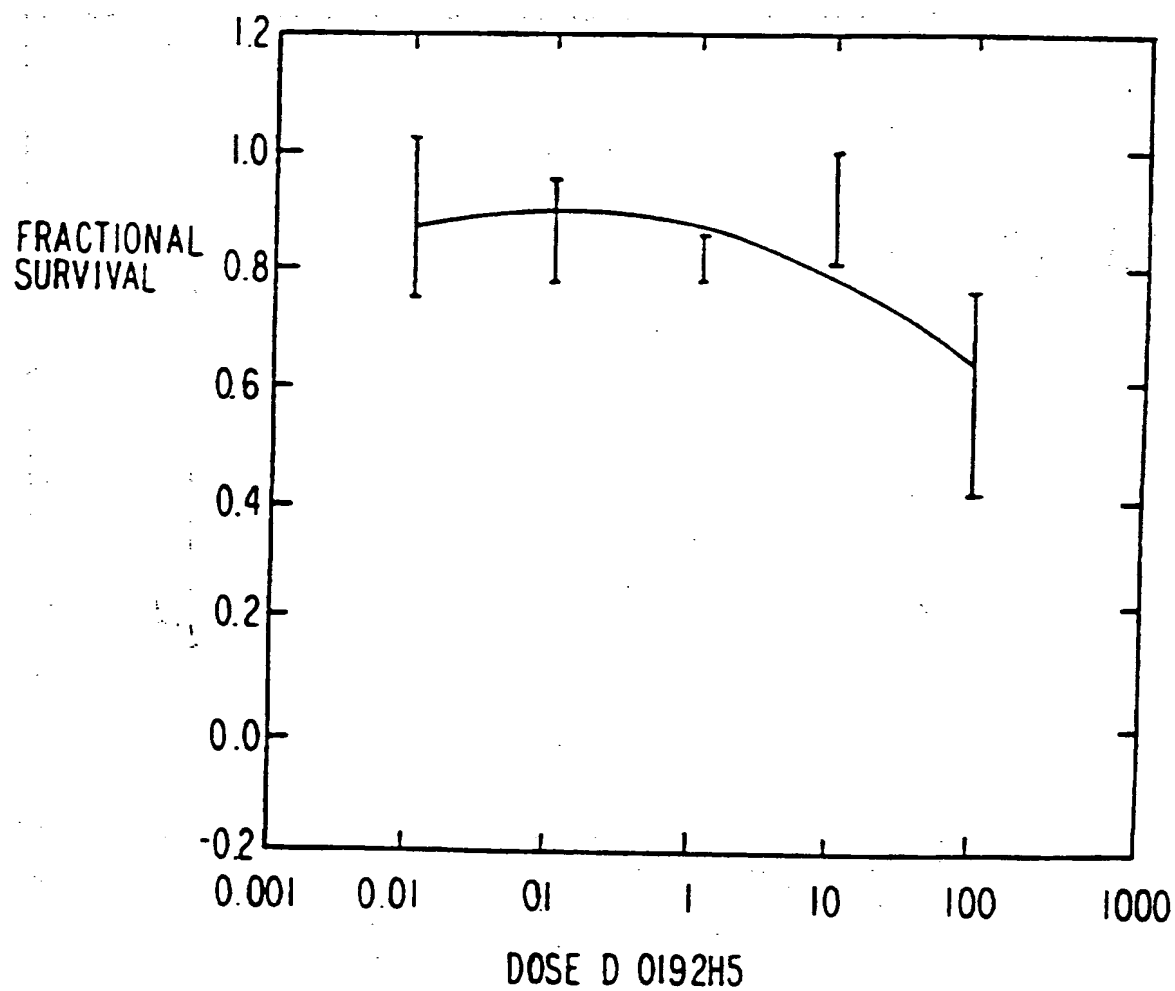
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FIG. 9C



SUBSTITUTE SHEET (RULE 26)

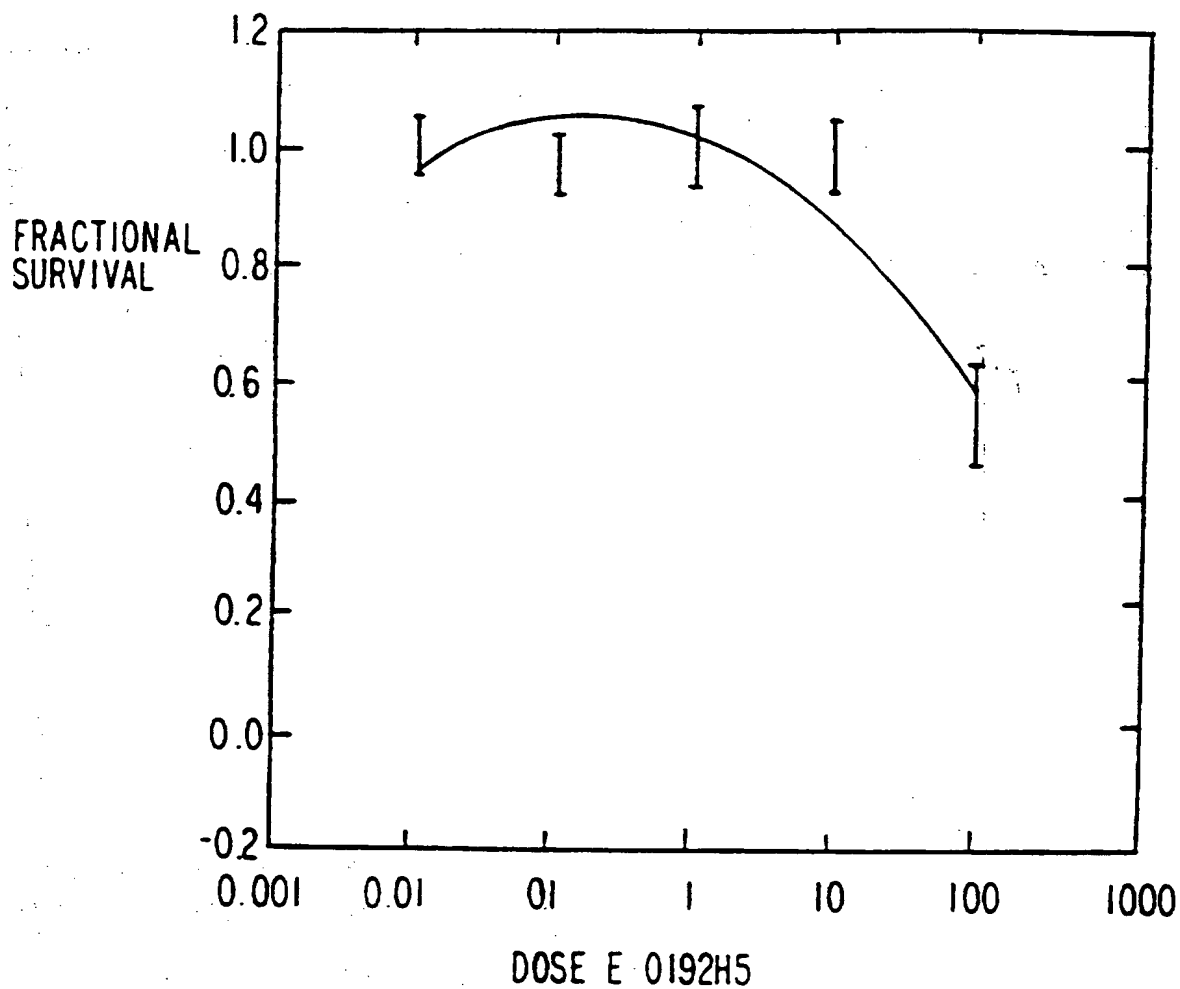
FIG. 9D





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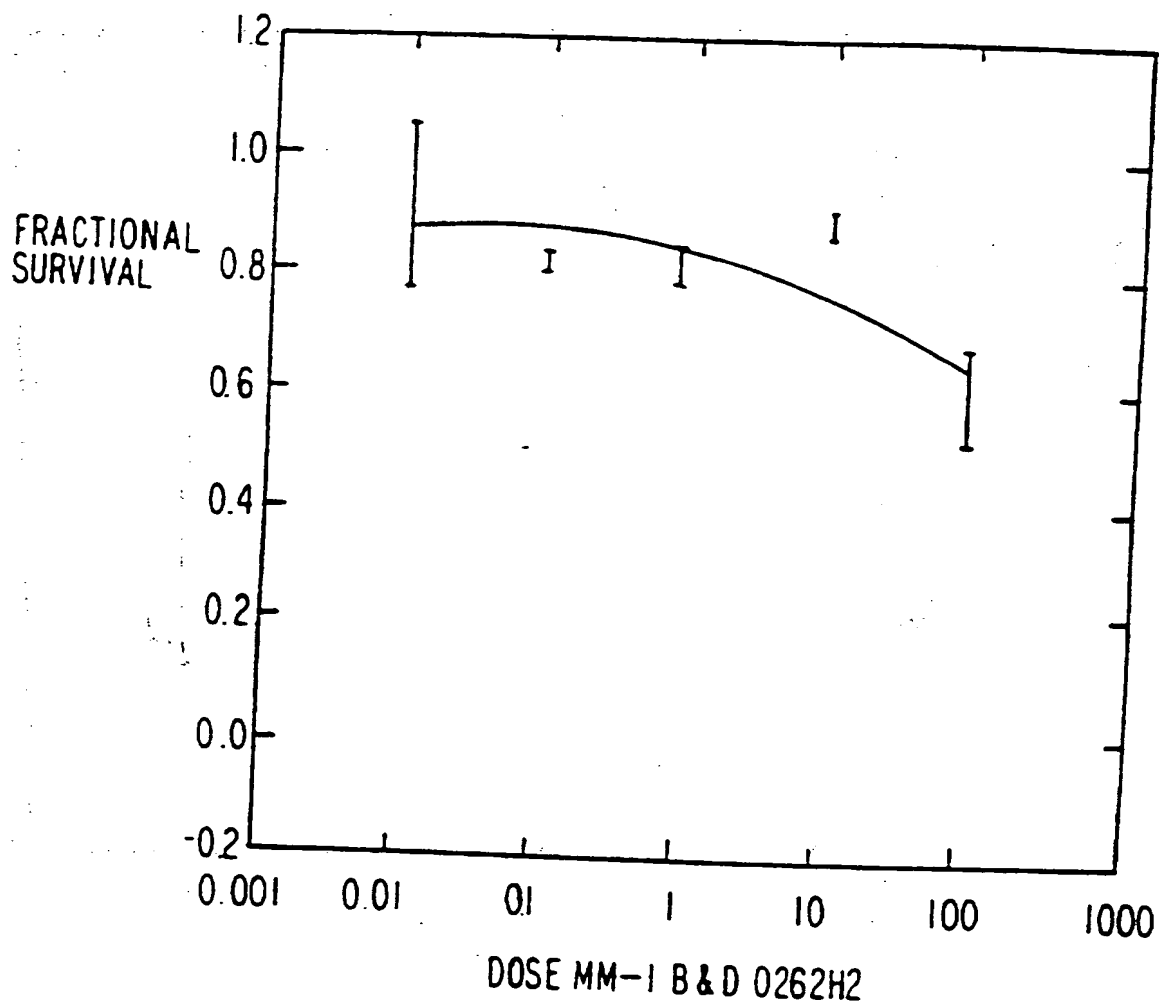
FIG. 9E



SUBSTITUTE SHEET (RULE 26)

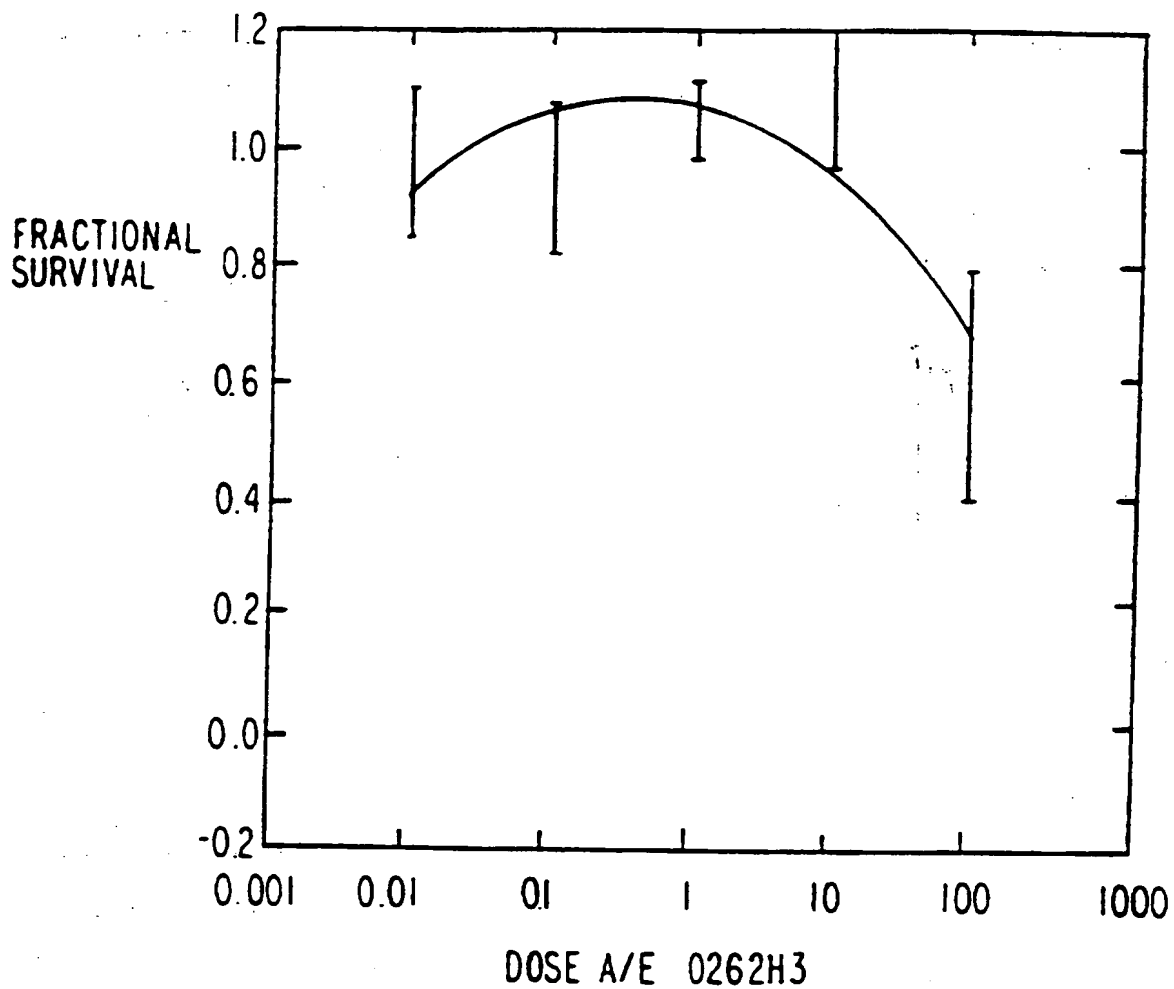
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FIG. 9F



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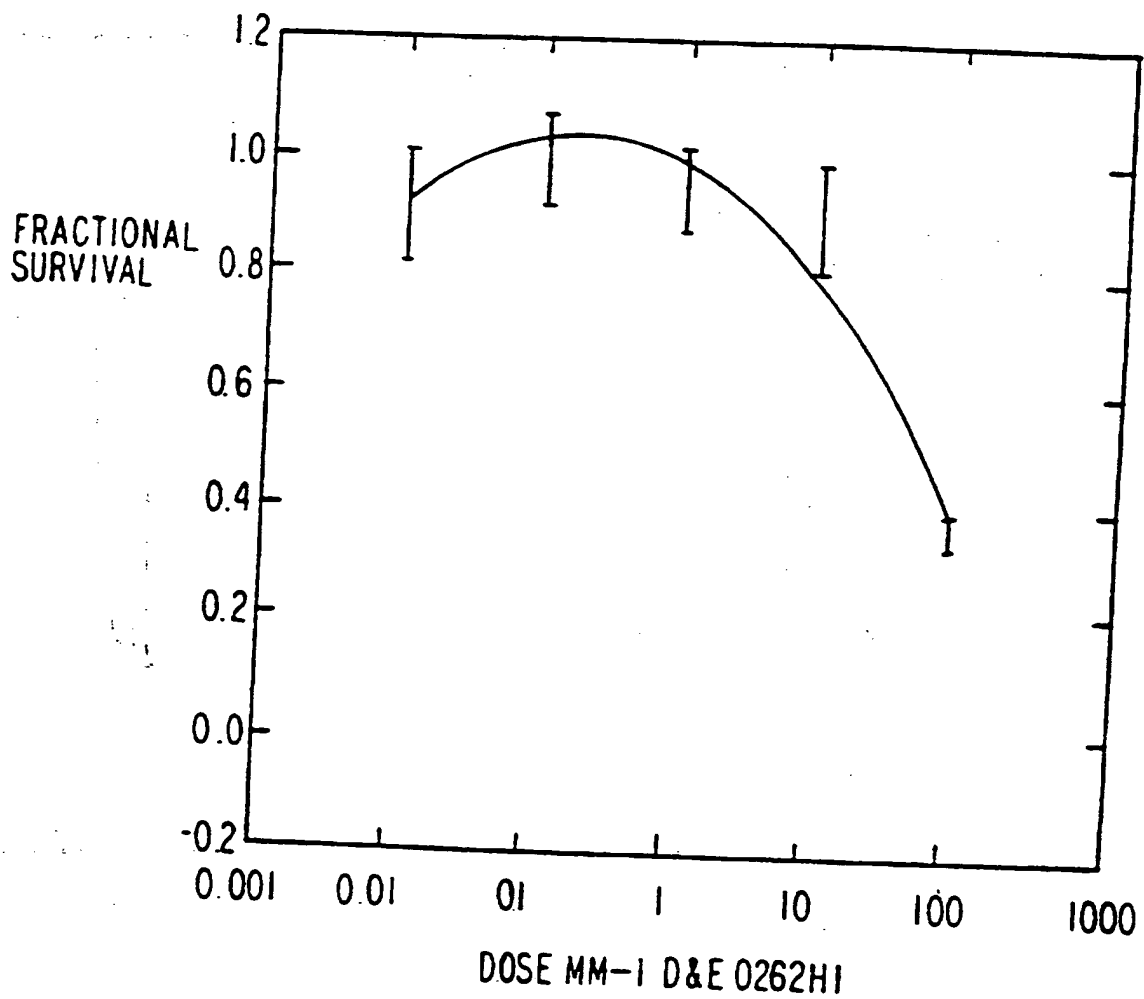
FIG. 9G



SUBSTITUTE SHEET (RULE 26)

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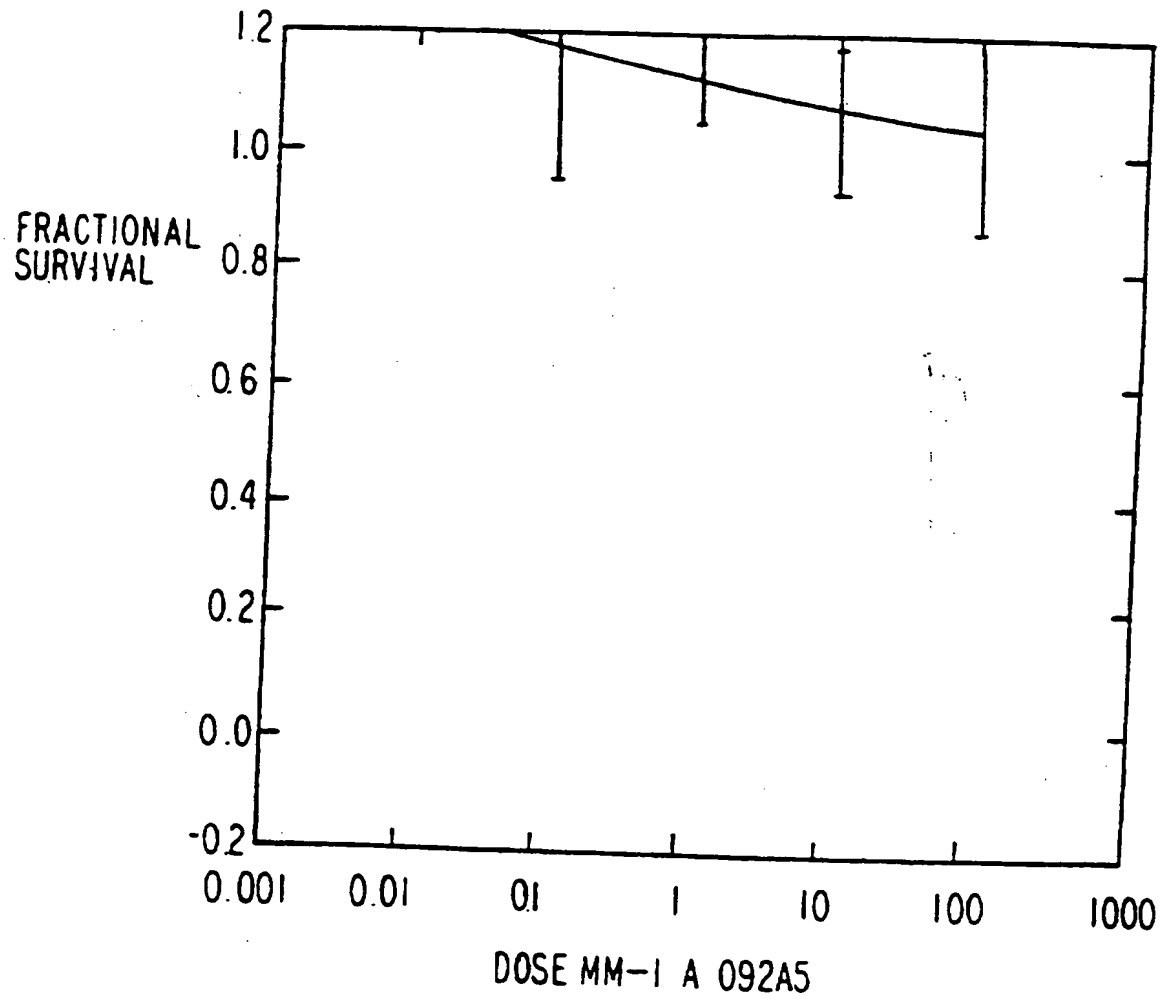
FIG. 9H



SUBSTITUTE SHEET (RULE 26)

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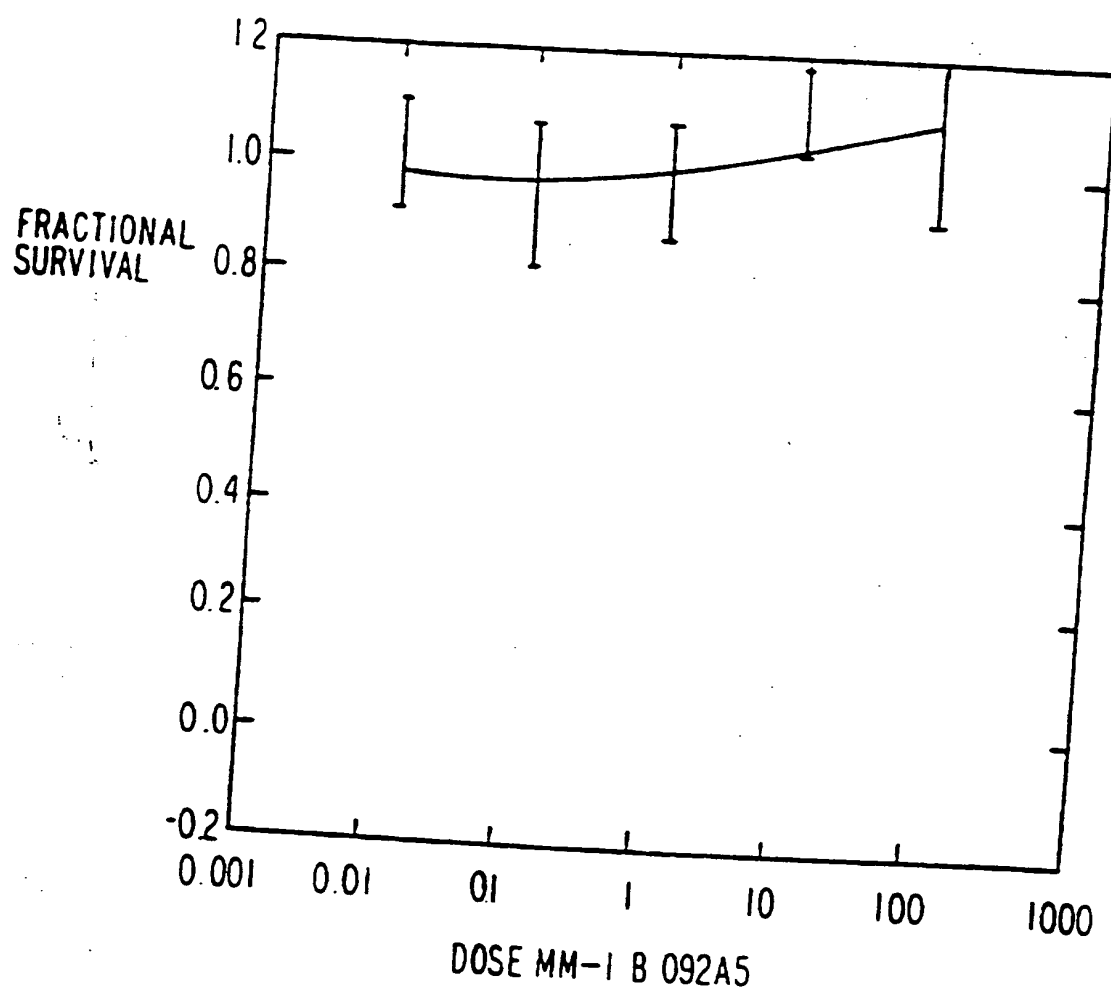
FIG. 10A



SUBSTITUTE SHEET (RULE 26)

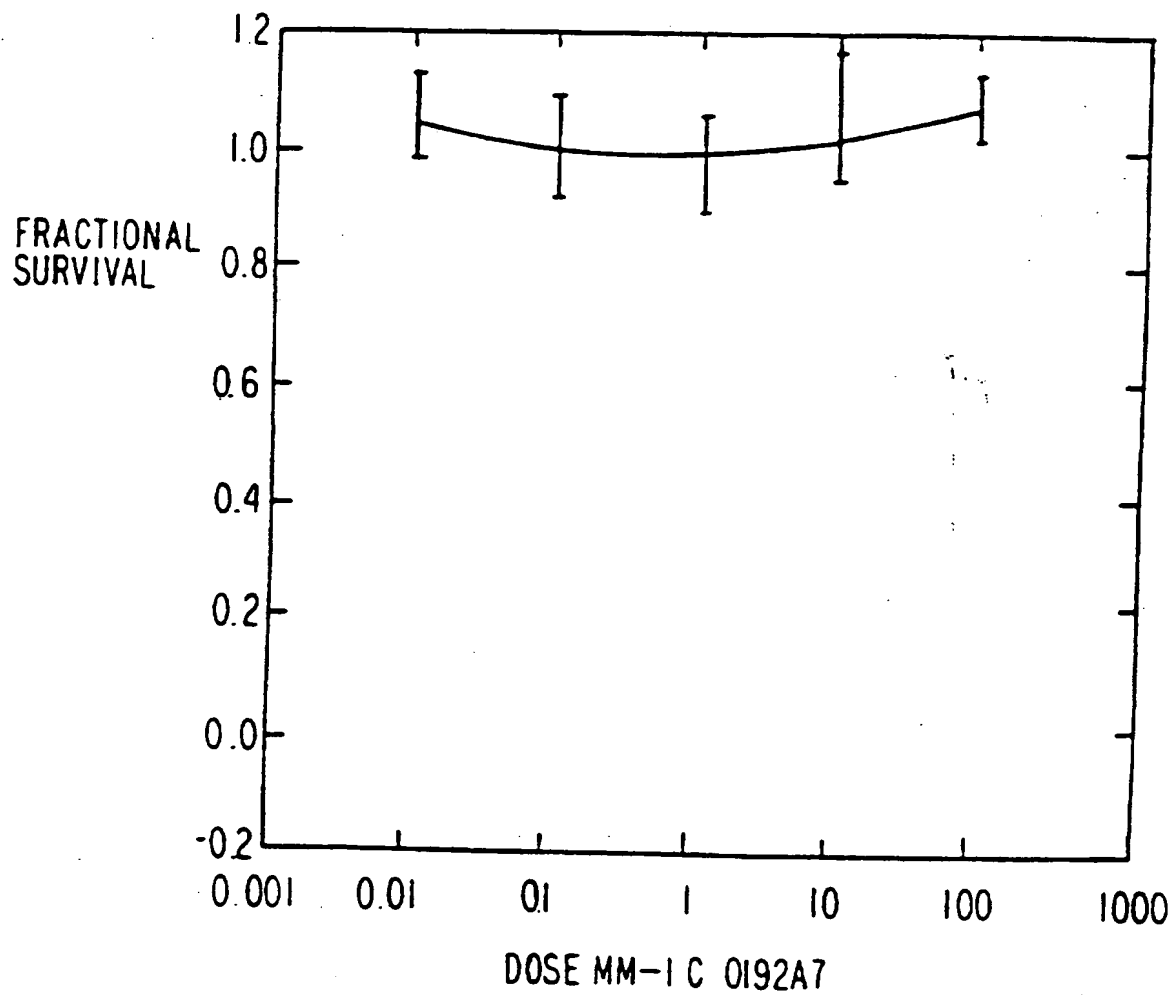
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FIG. 10B



SUBSTITUTE SHEET (RULE 26)

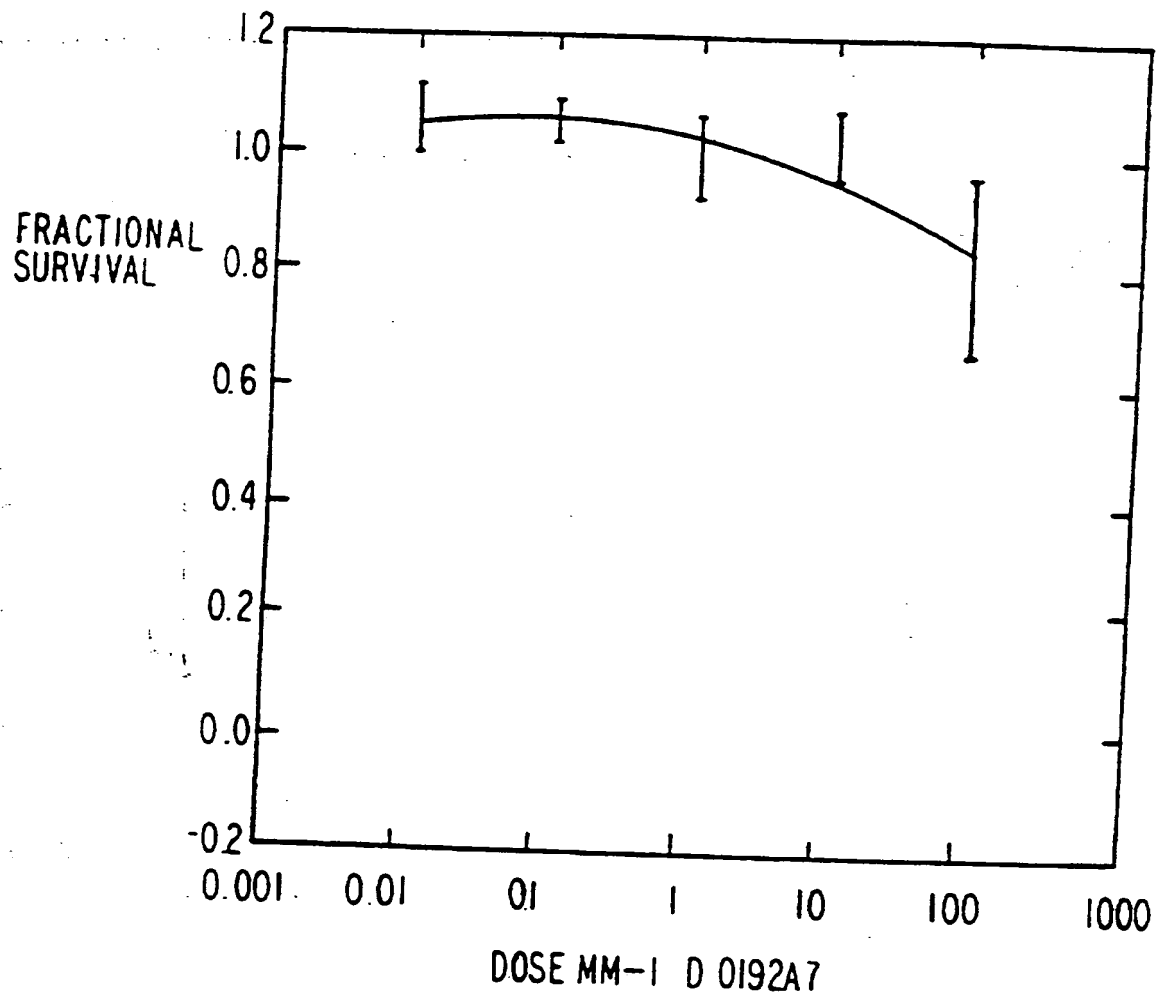
FIG. 10C



SUBSTITUTE SHEET (RULE 26)

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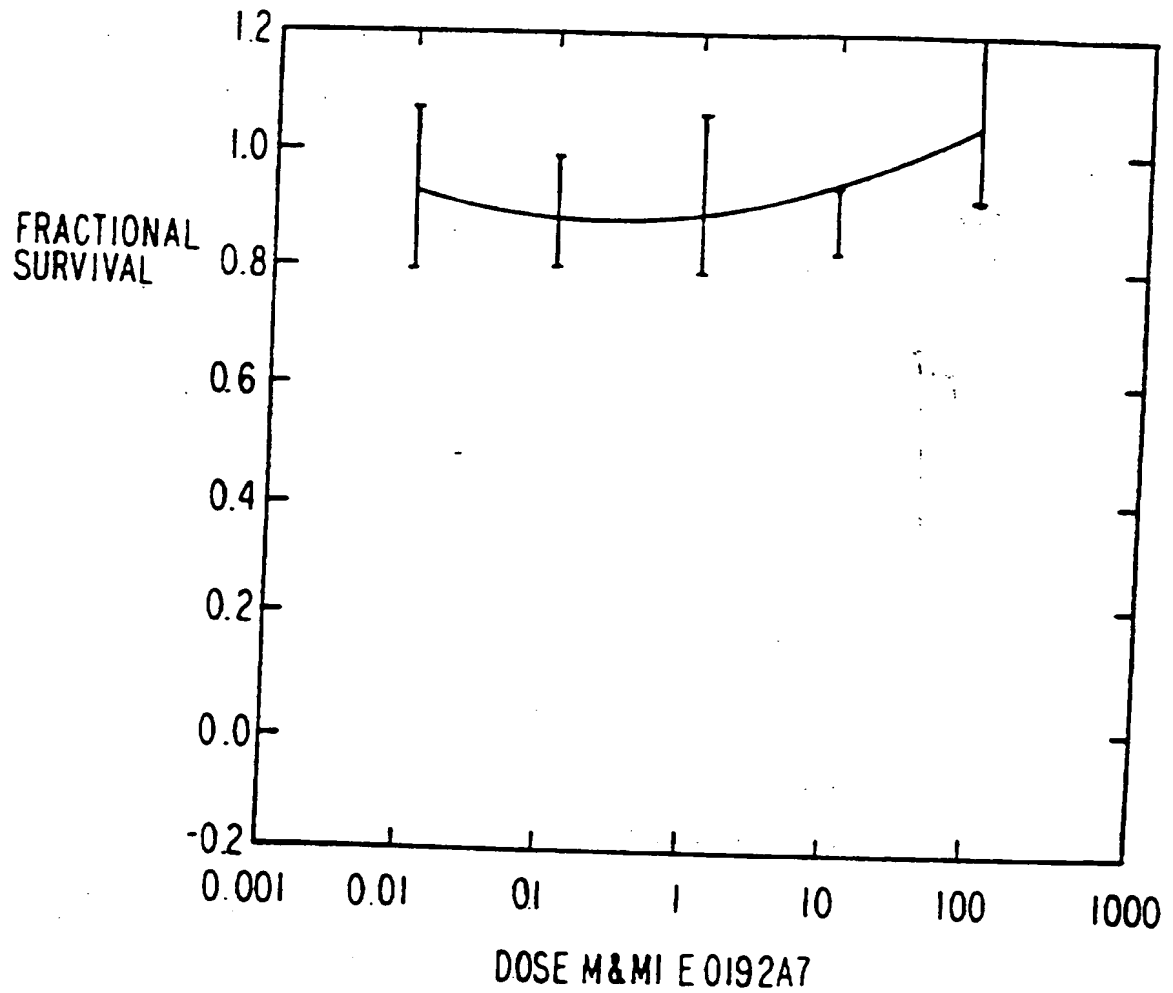
FIG. 10D





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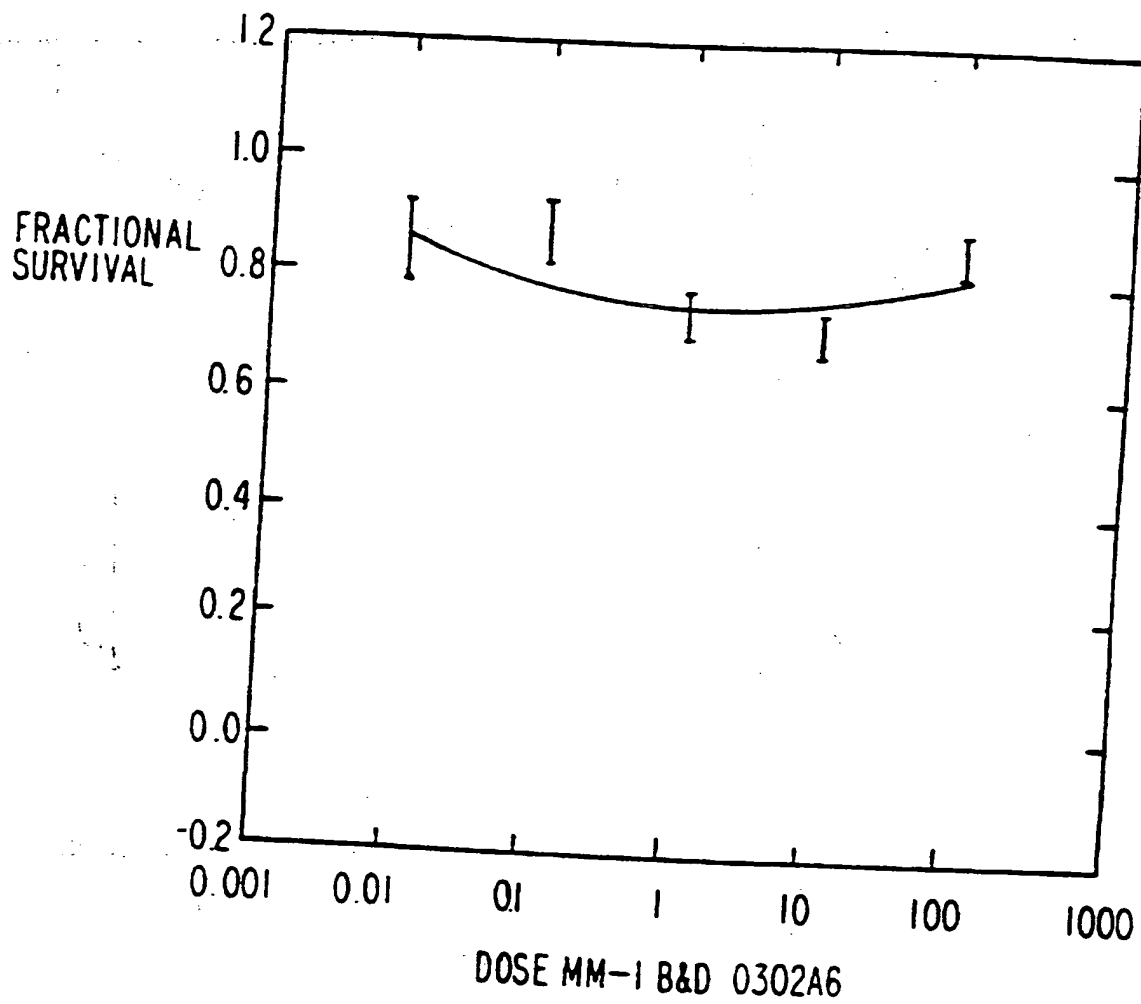
FIG. 10E



SUBSTITUTE SHEET (RULE 26)

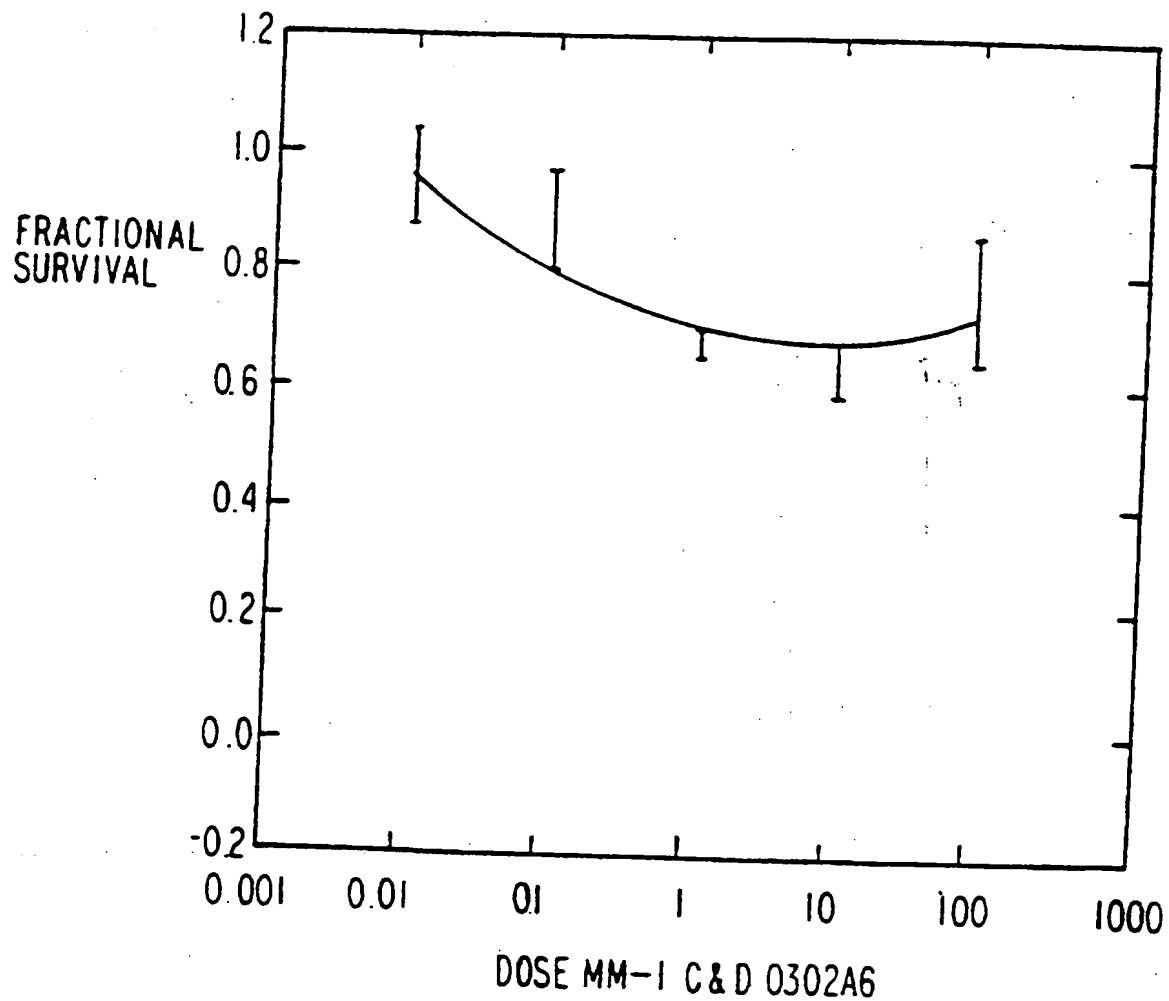
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FIG. 10F



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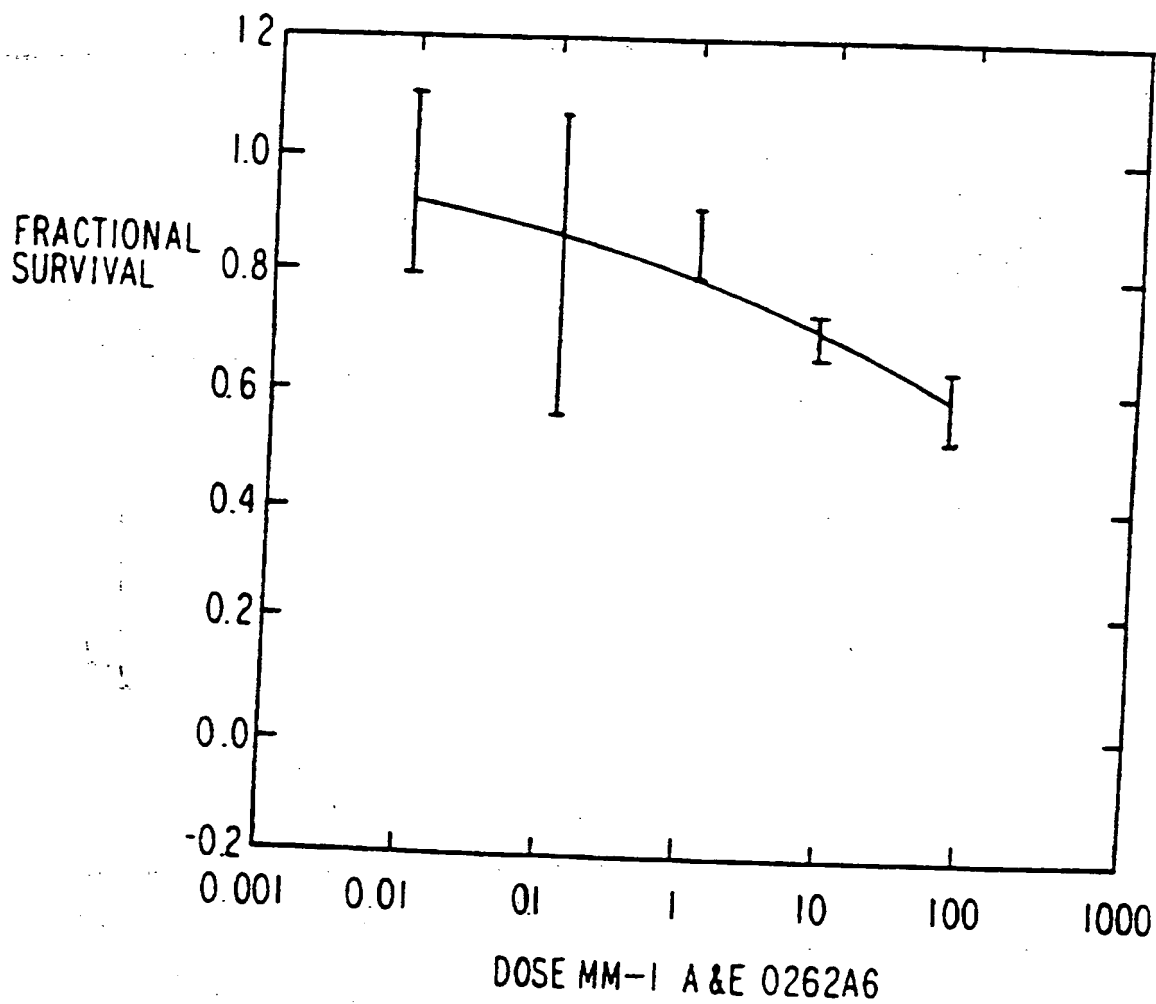
FIG. 10G



SUBSTITUTE SHEET (RULE 26)

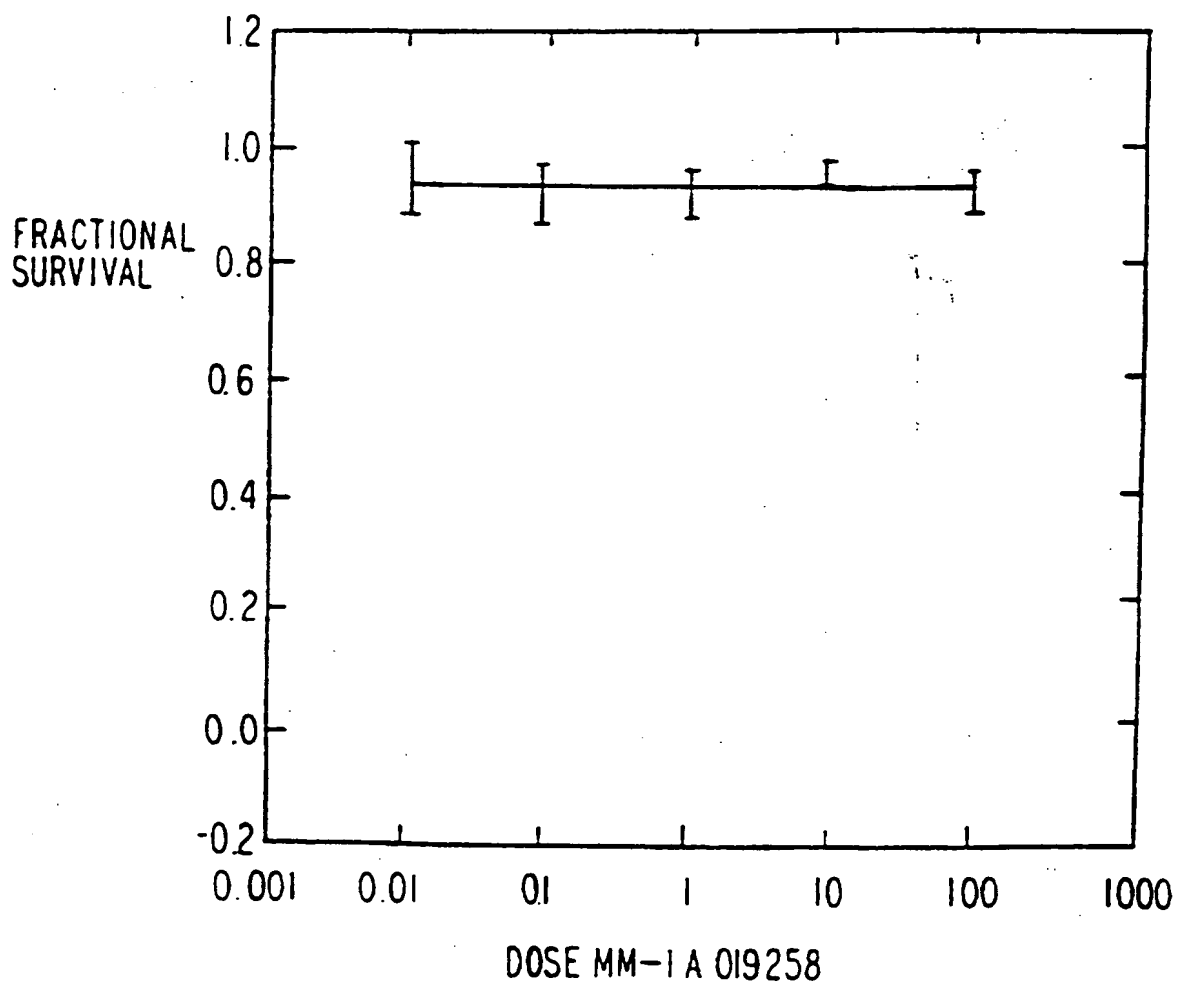
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FIG. 10H



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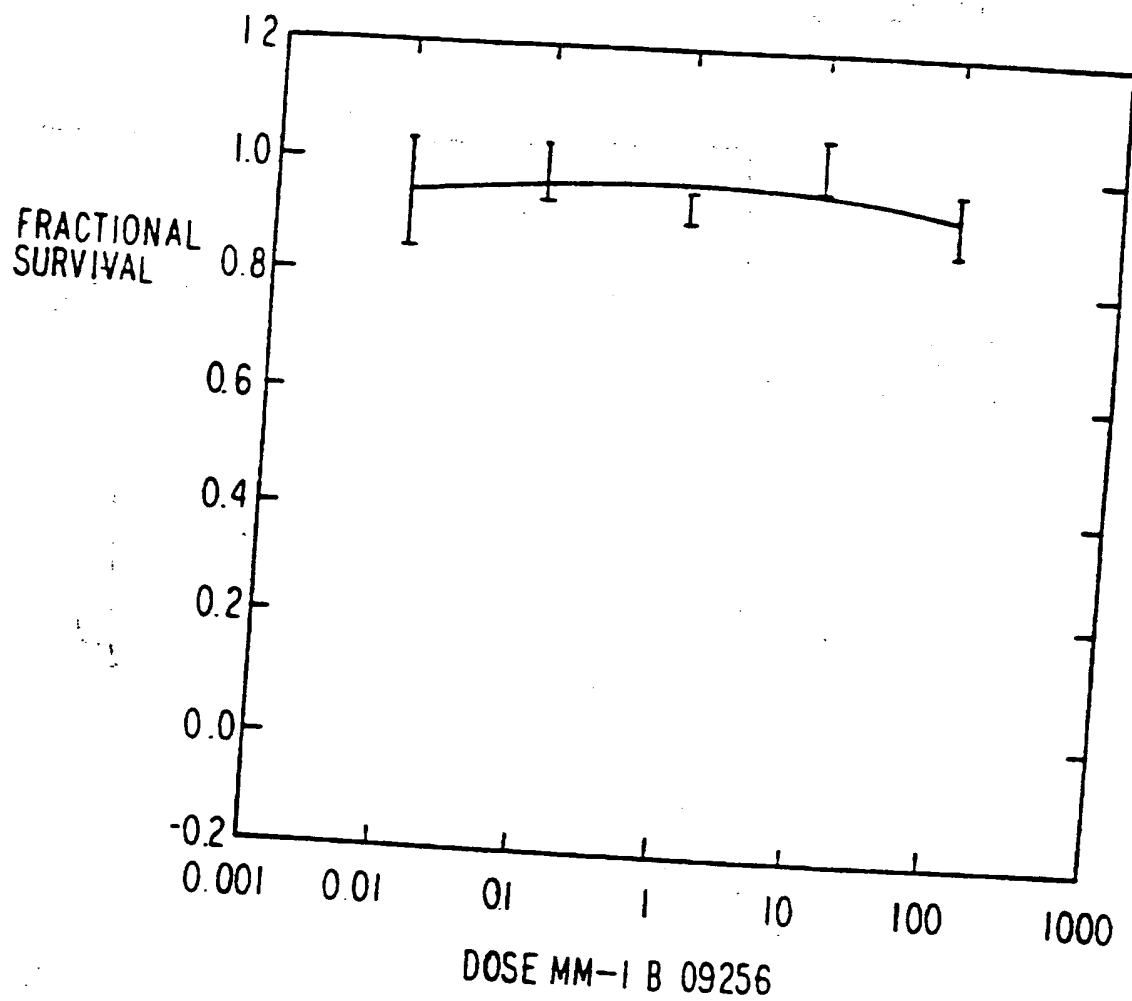
FIG. 11A



SUBSTITUTE SHEET (RULE 26)

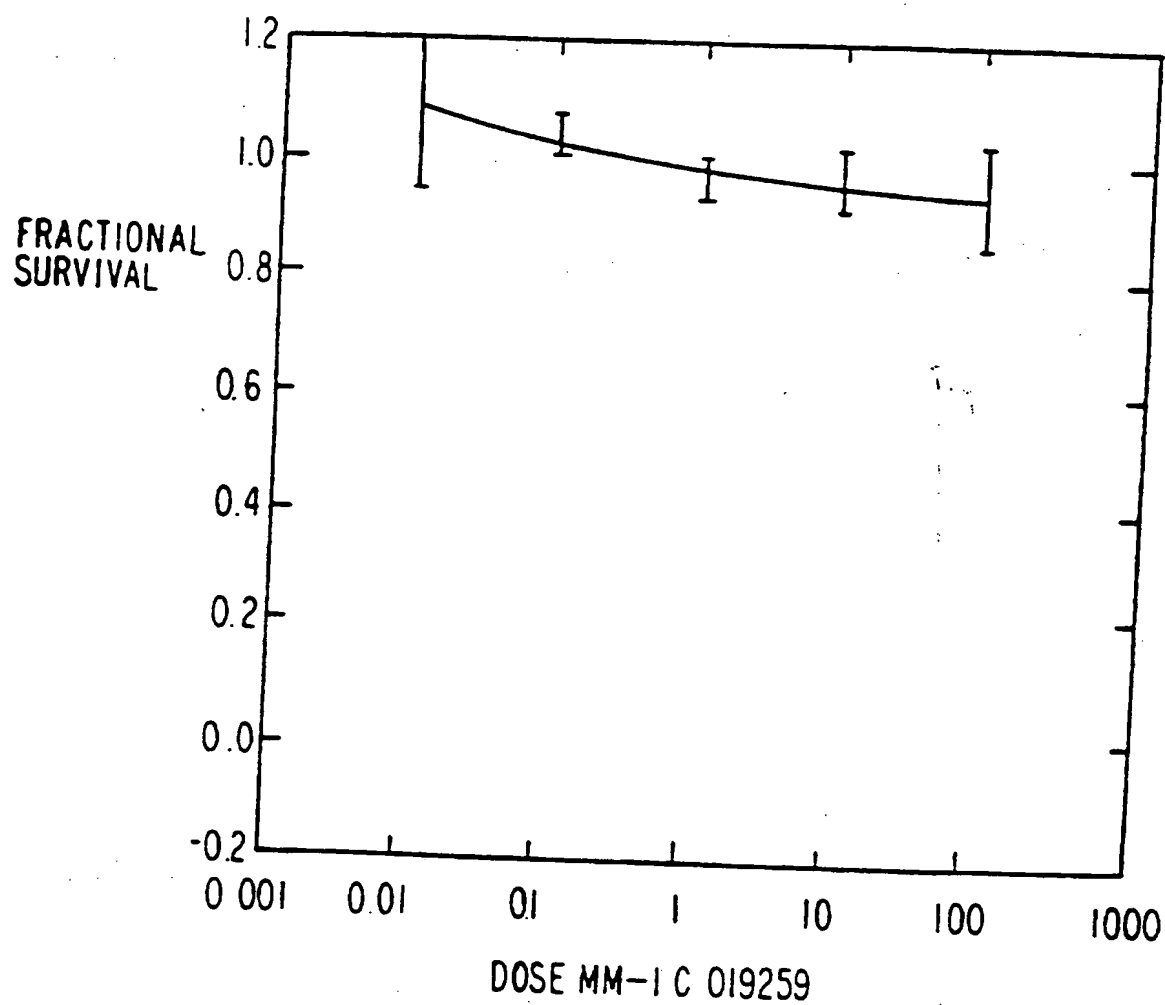
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FIG. 1/B



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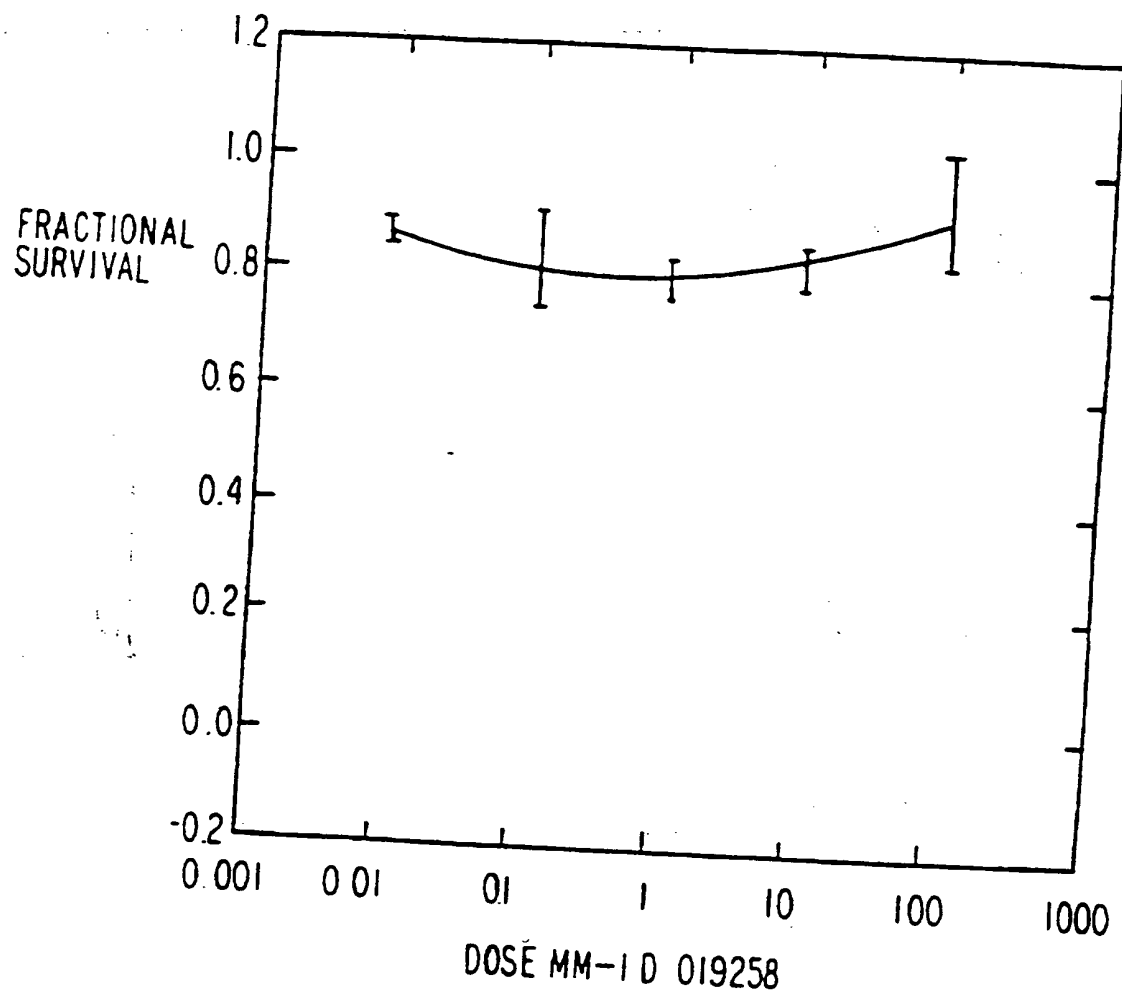
FIG. 1 IC



SUBSTITUTE SHEET (RULE 26)

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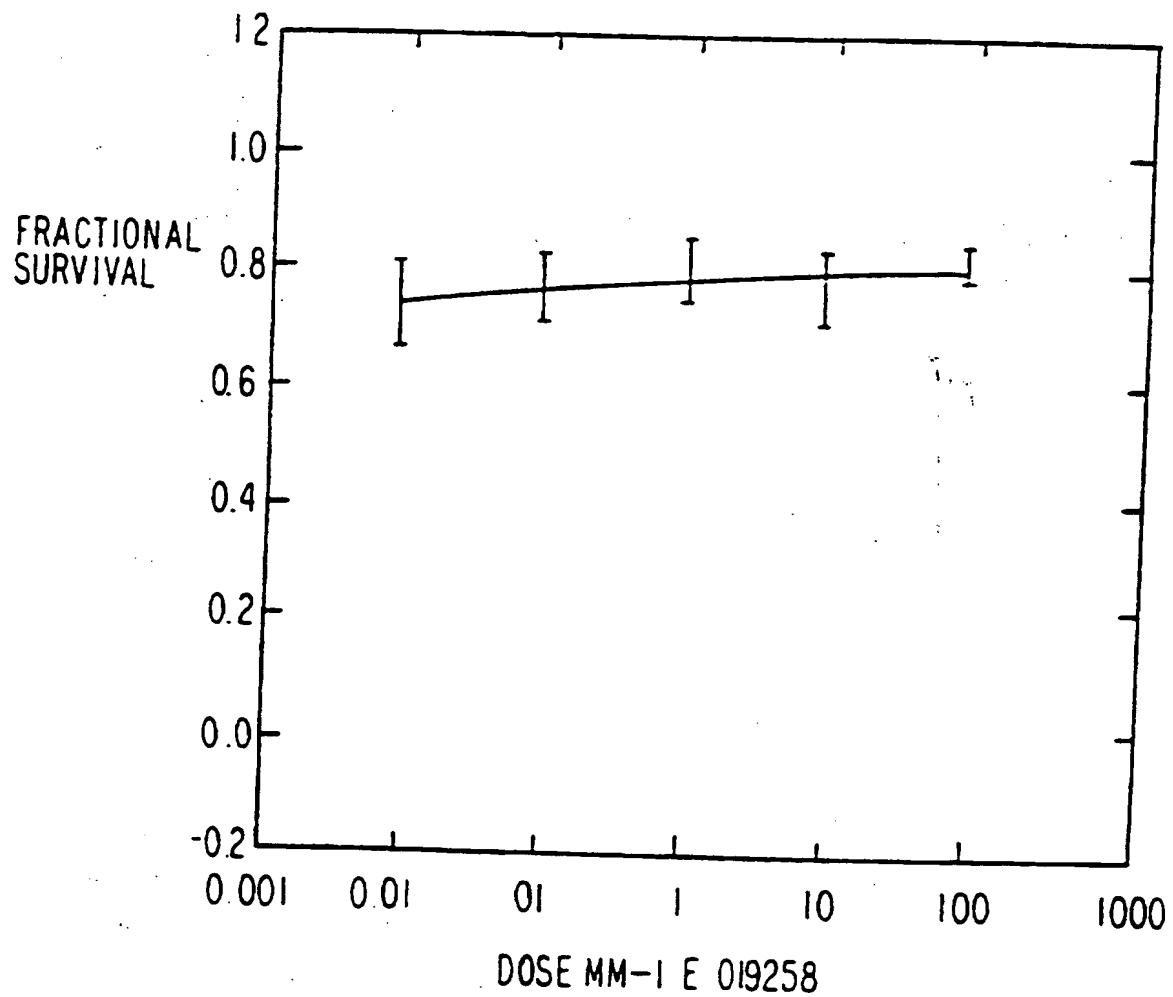
FIG. 11D





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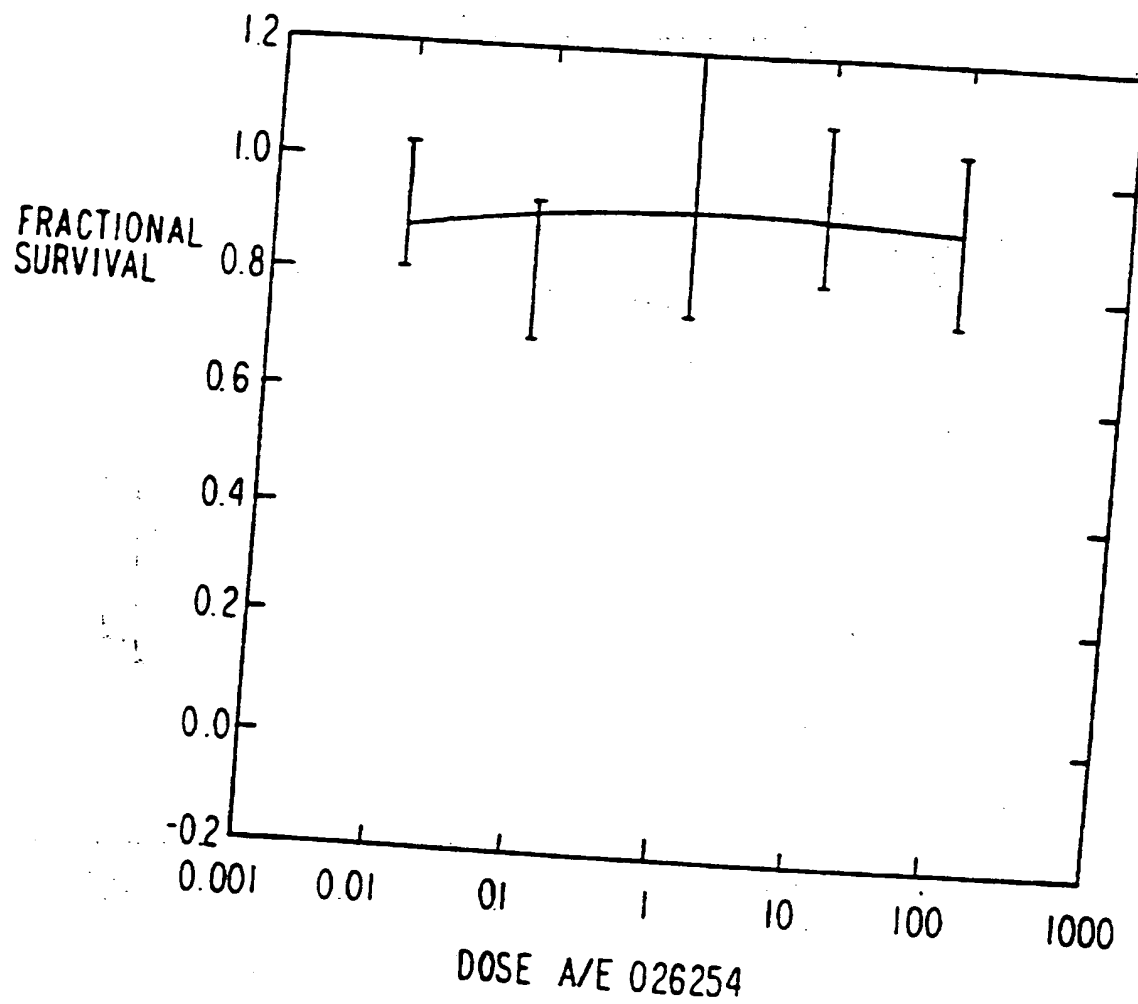
FIG. 11E



SUBSTITUTE SHEET (RULE 26)

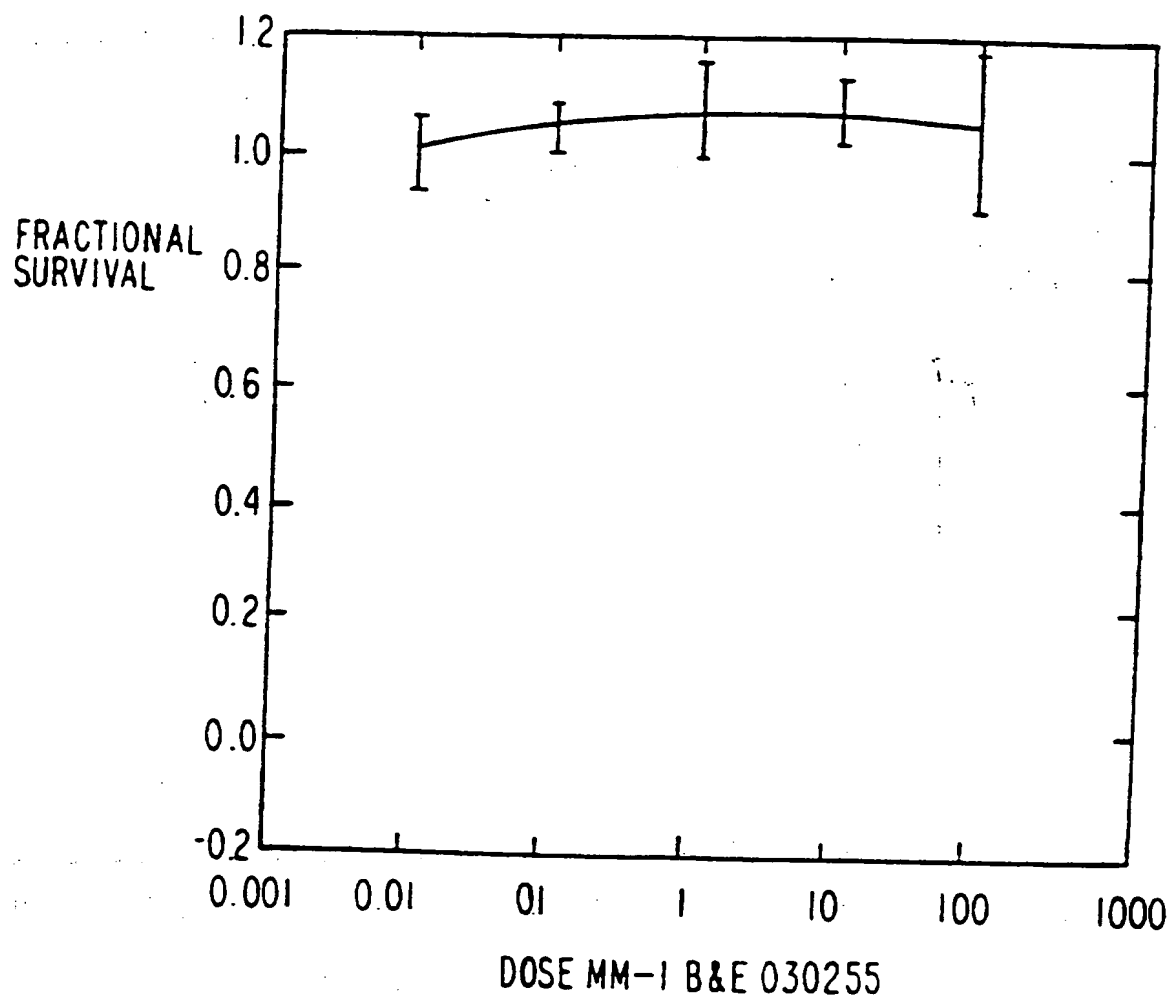
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FIG. 11F



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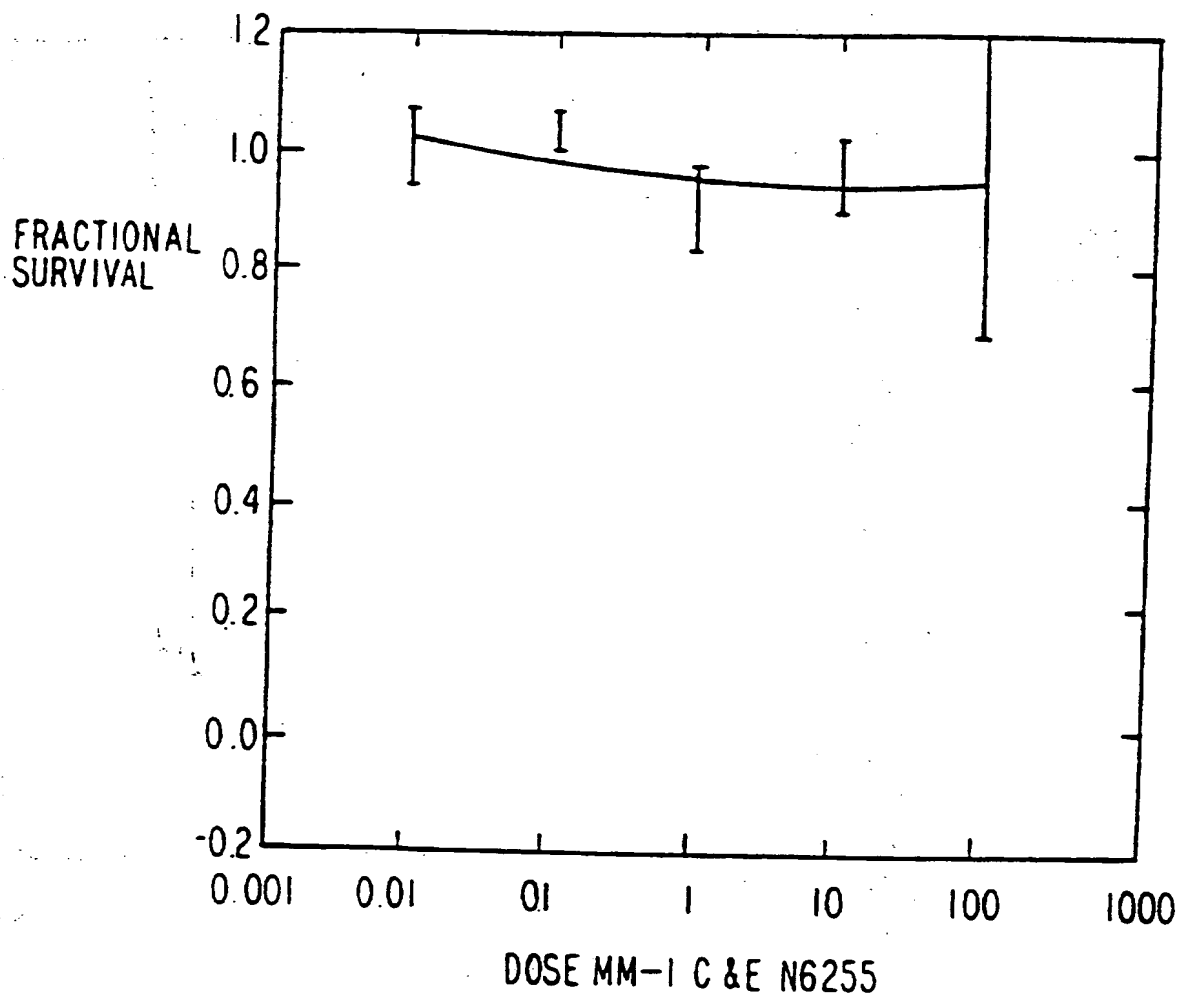
FIG. 11G



SUBSTITUTE SHEET (RULE 26)

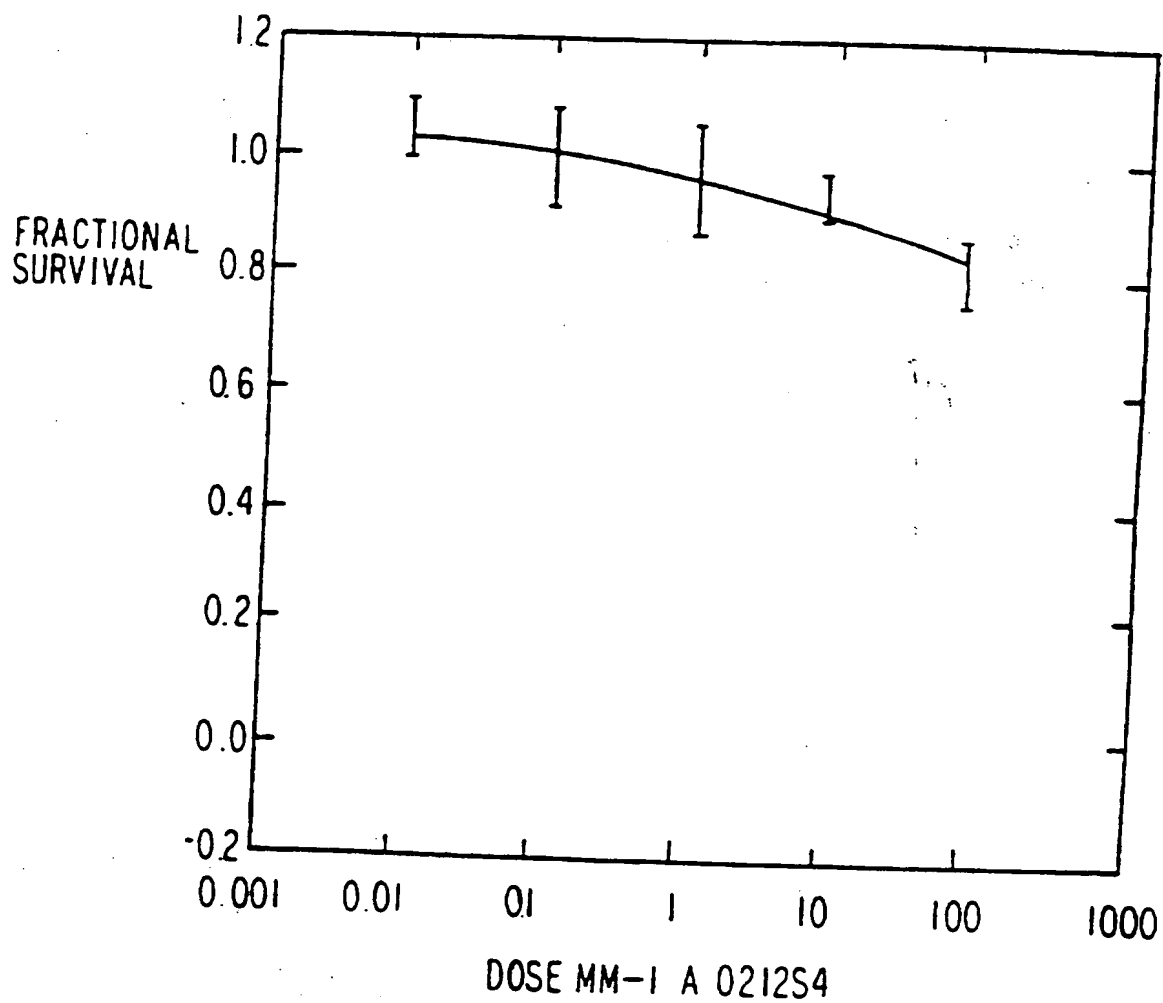
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FIG. 11H



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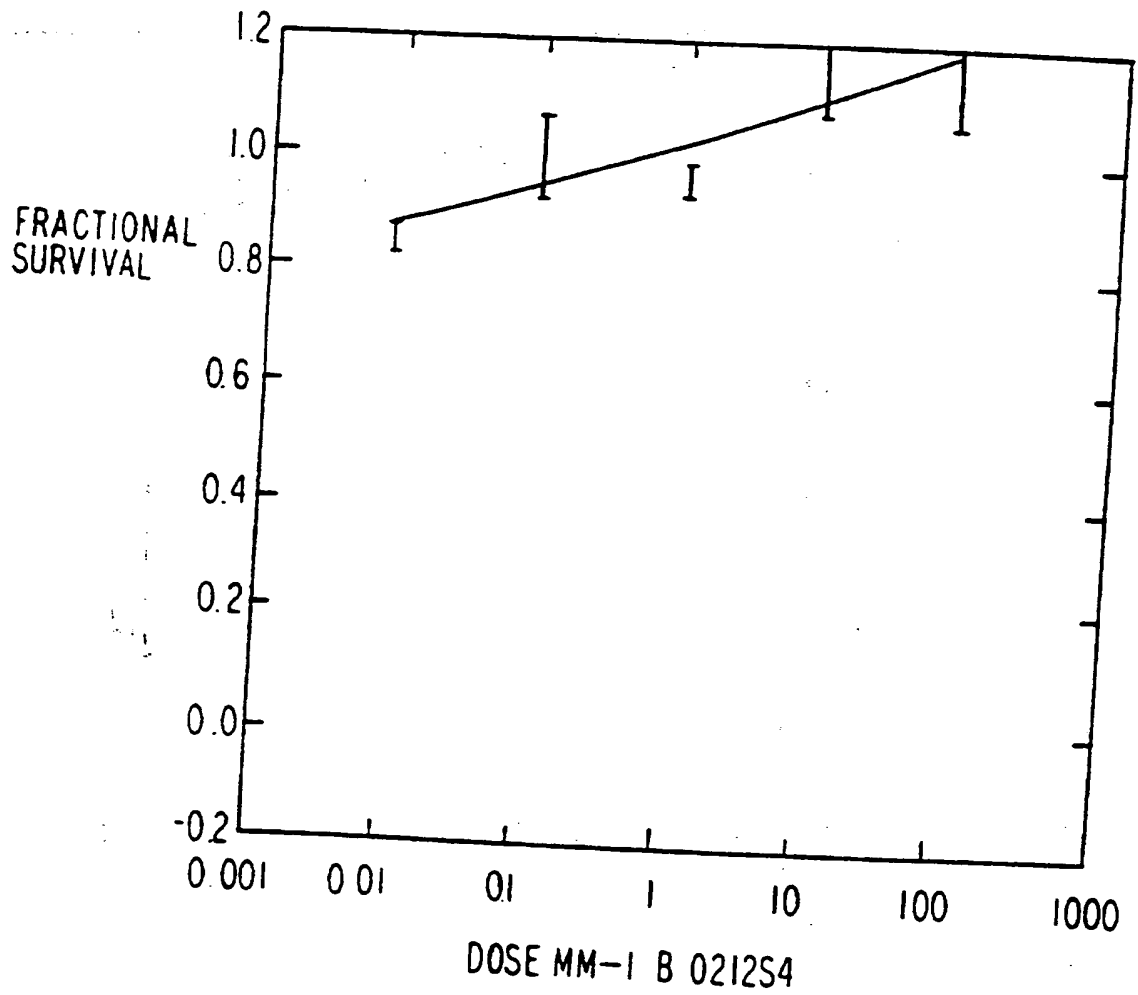
FIG. 12A



SUBSTITUTE SHEET (RULE 26)

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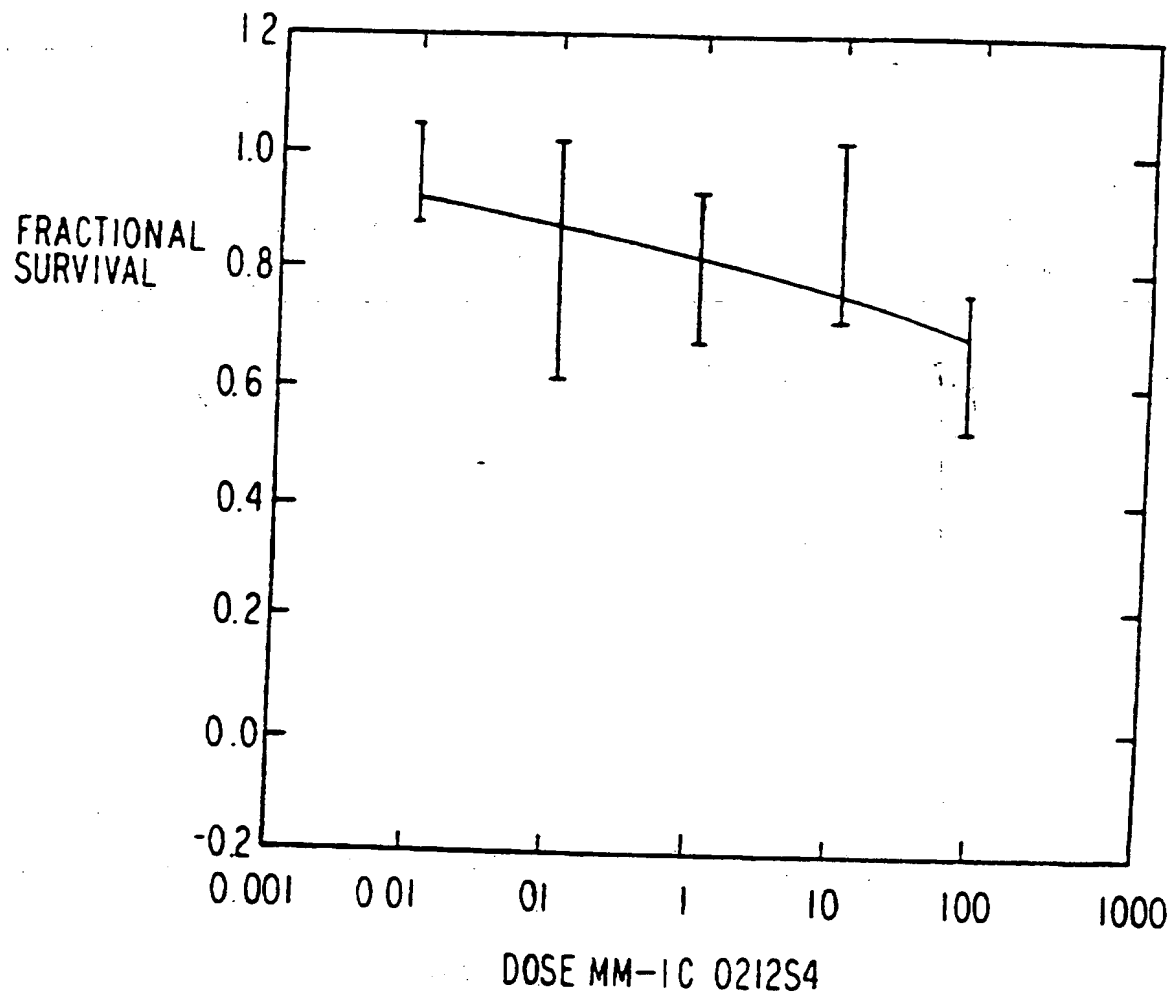
FIG. 12B



SUBSTITUTE SHEET (RULE 26)

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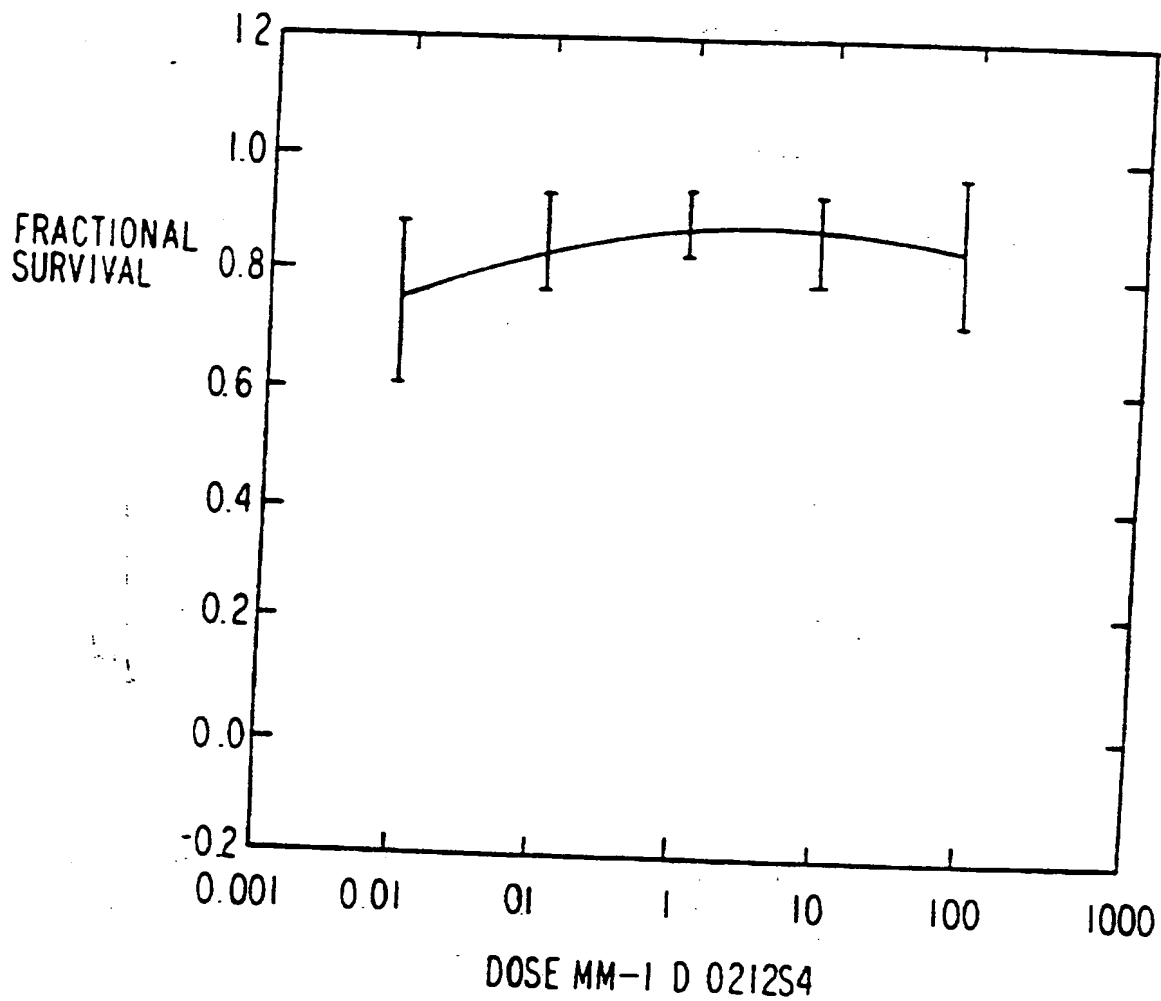
FIG. 12C



SUBSTITUTE SHEET (RULE 26)

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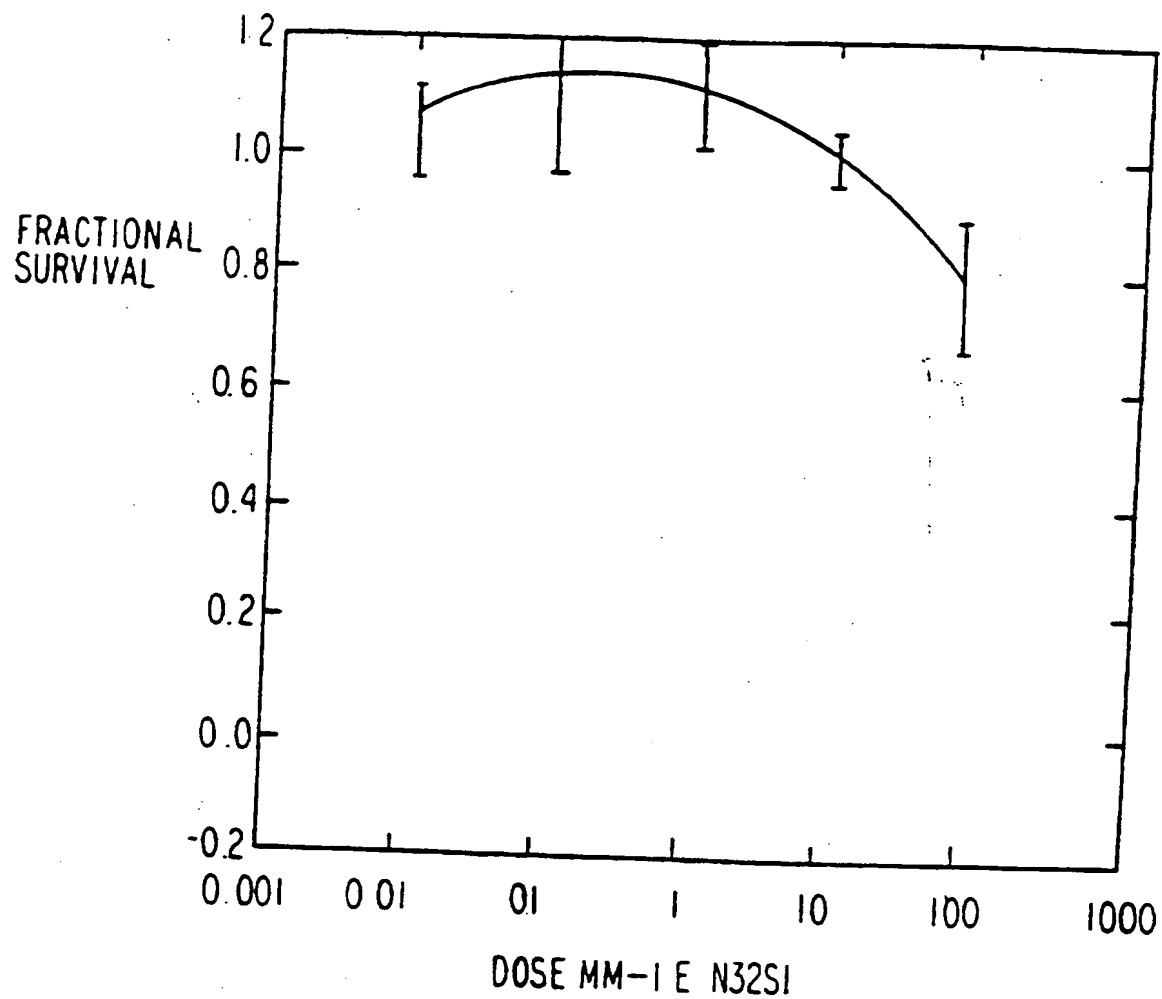
FIG. 12D





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FIG. 12E



SUBSTITUTE SHEET (RULE 26)

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FIG. 12F

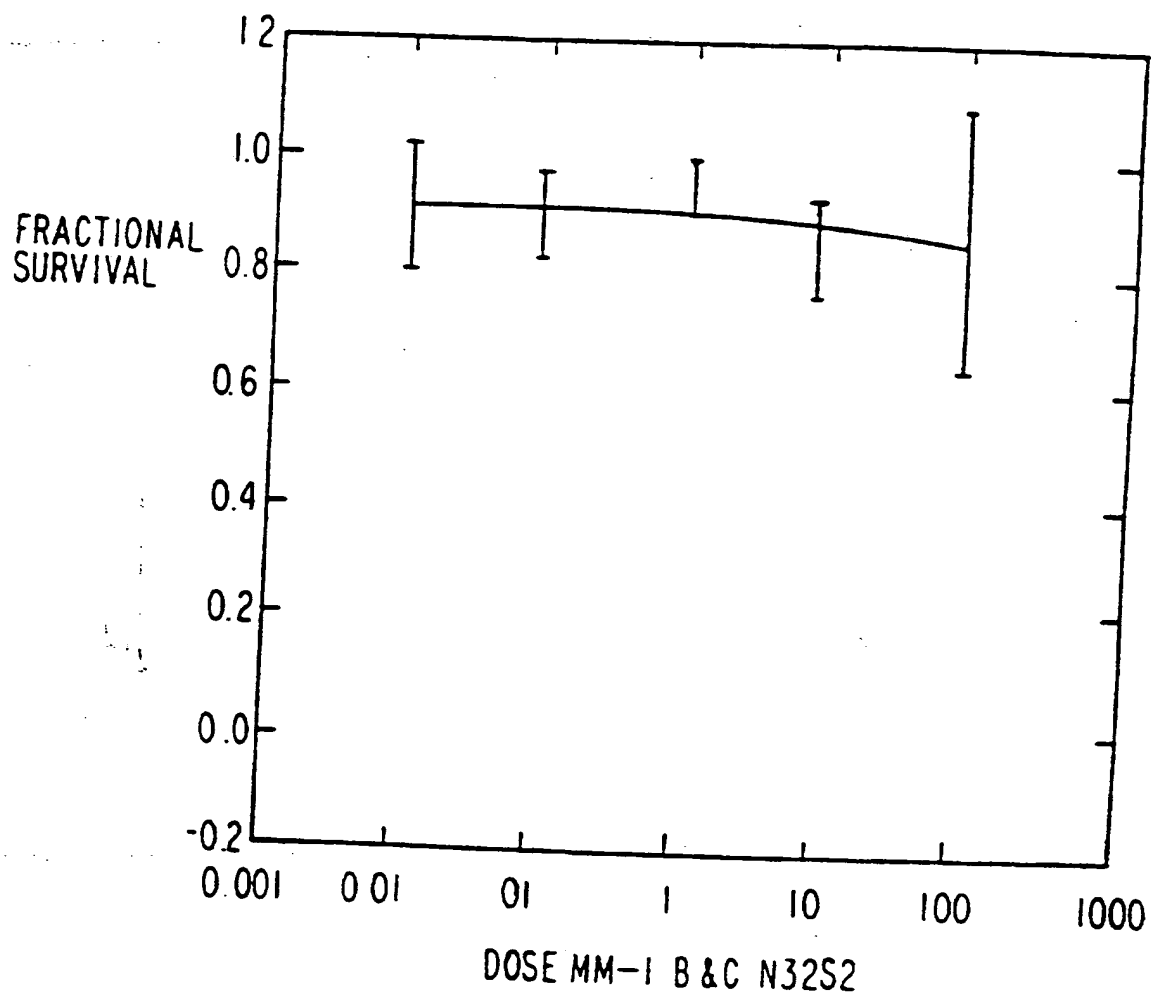
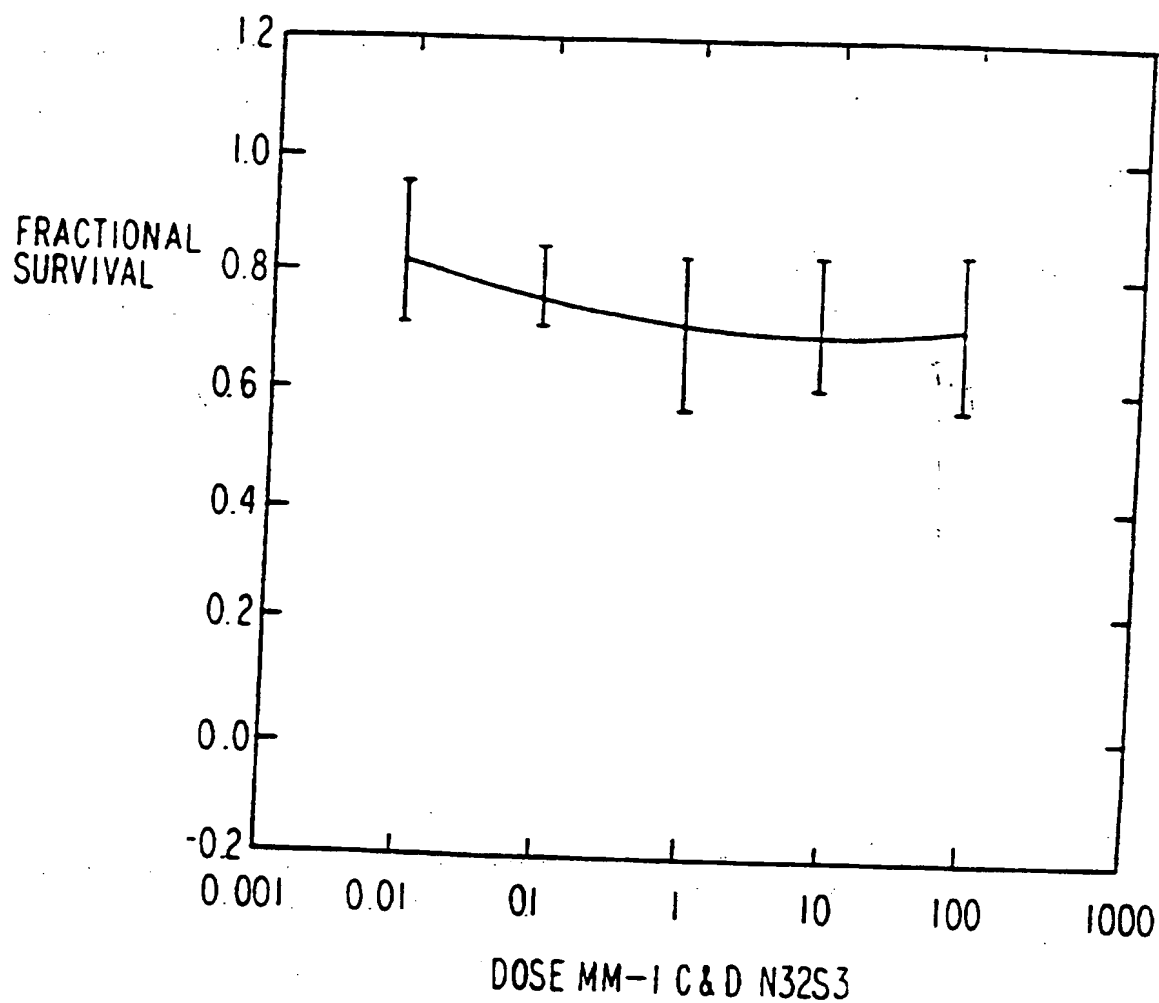


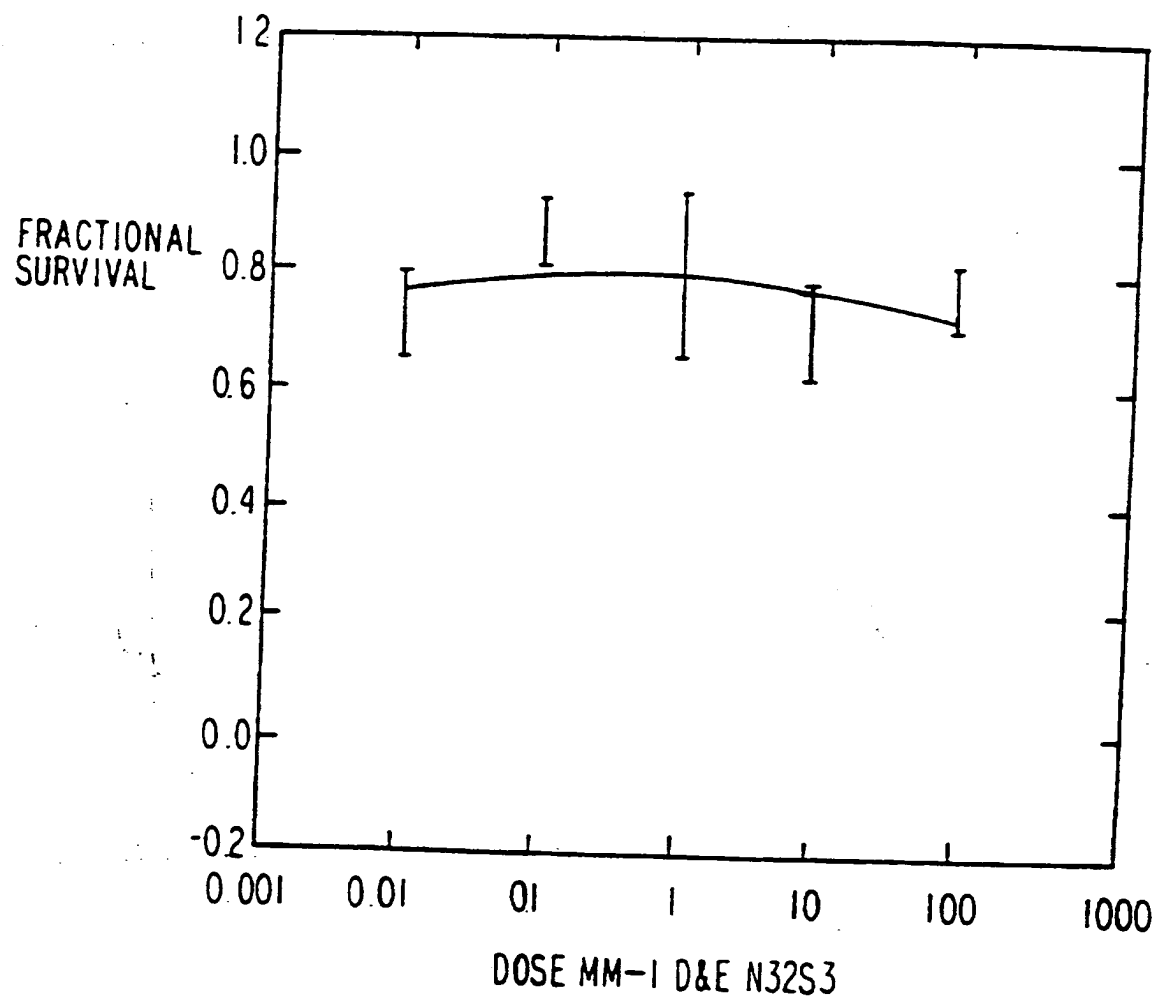
FIG. 12G



SUBSTITUTE SHEET (RULE 26)

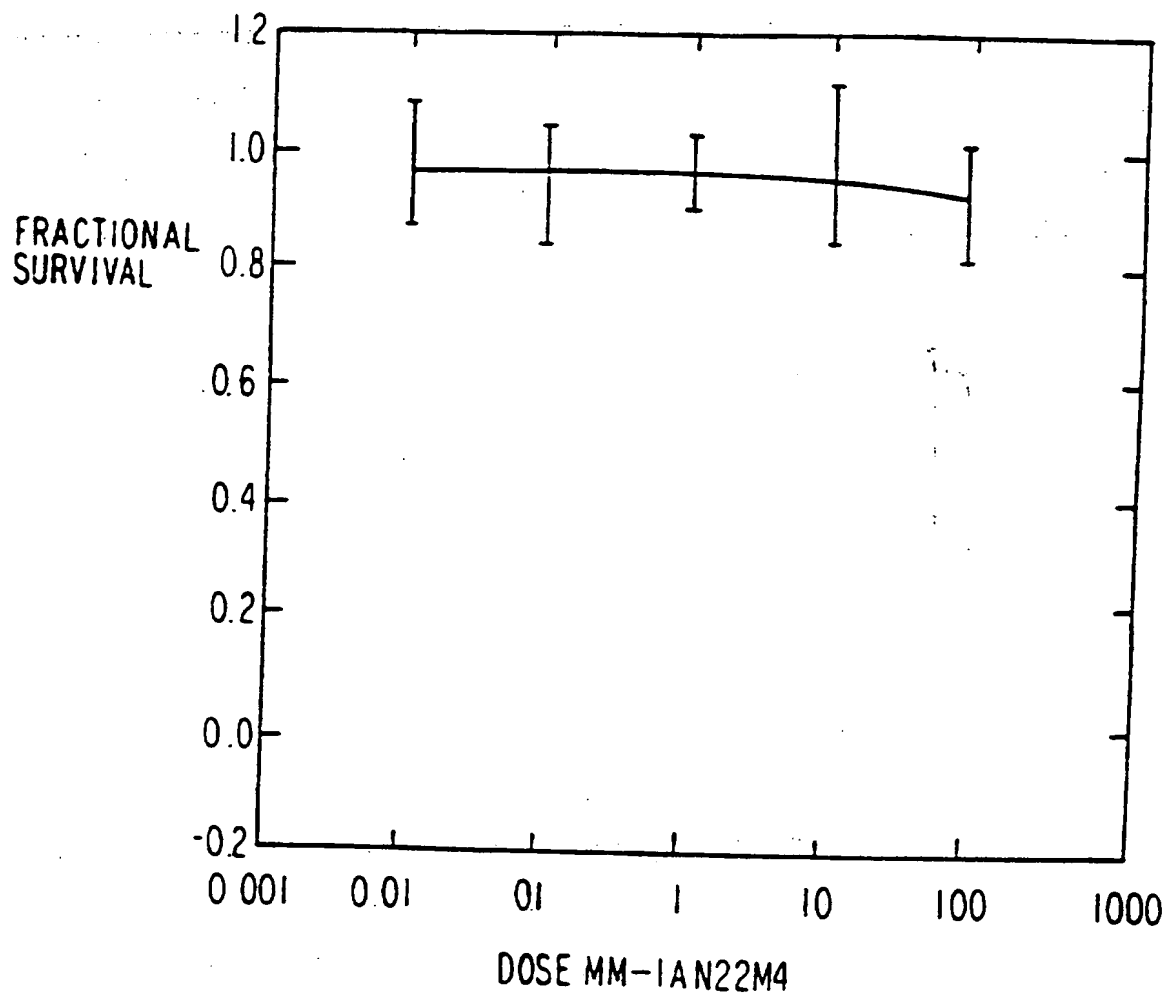
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FIG. 12H



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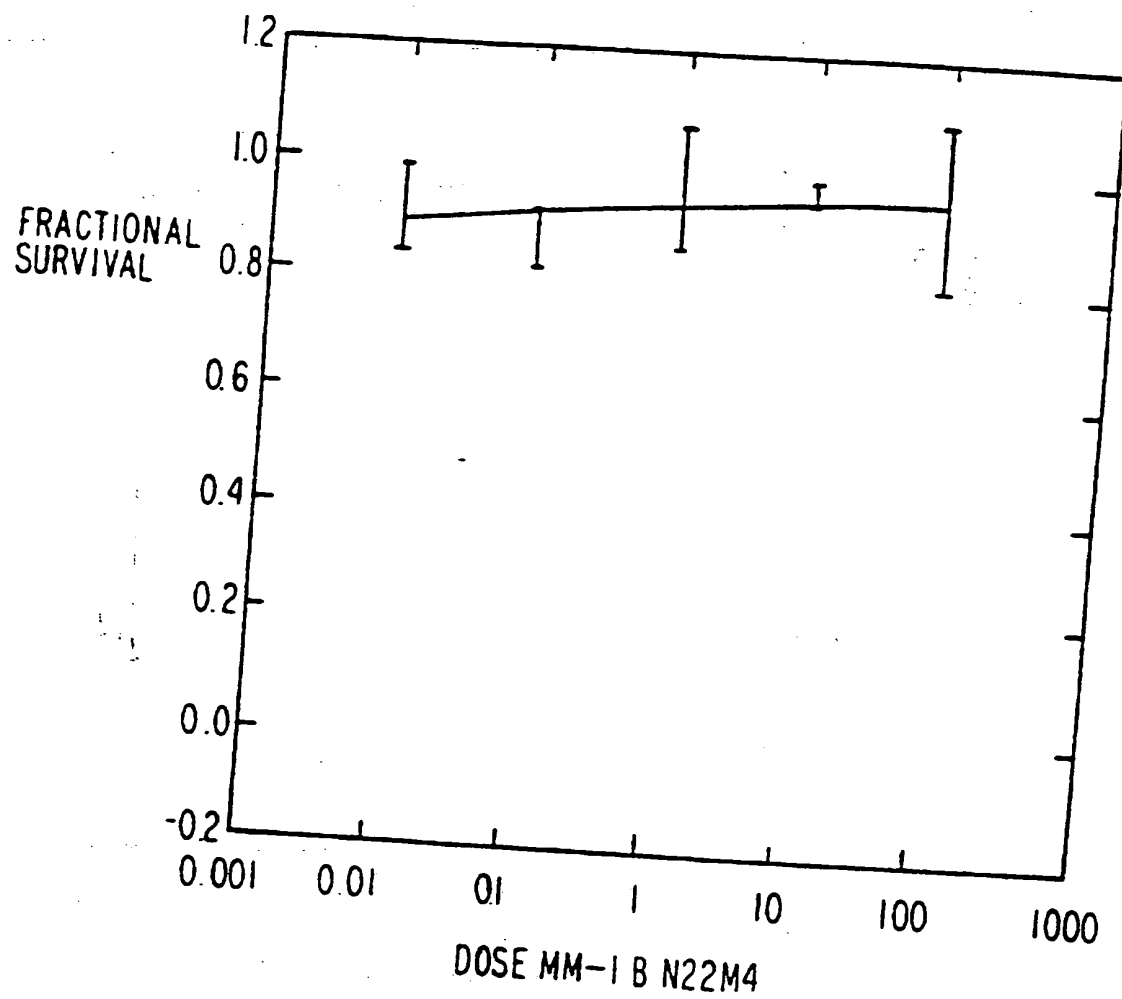
FIG. 13A



SUBSTITUTE SHEET (RULE 26)

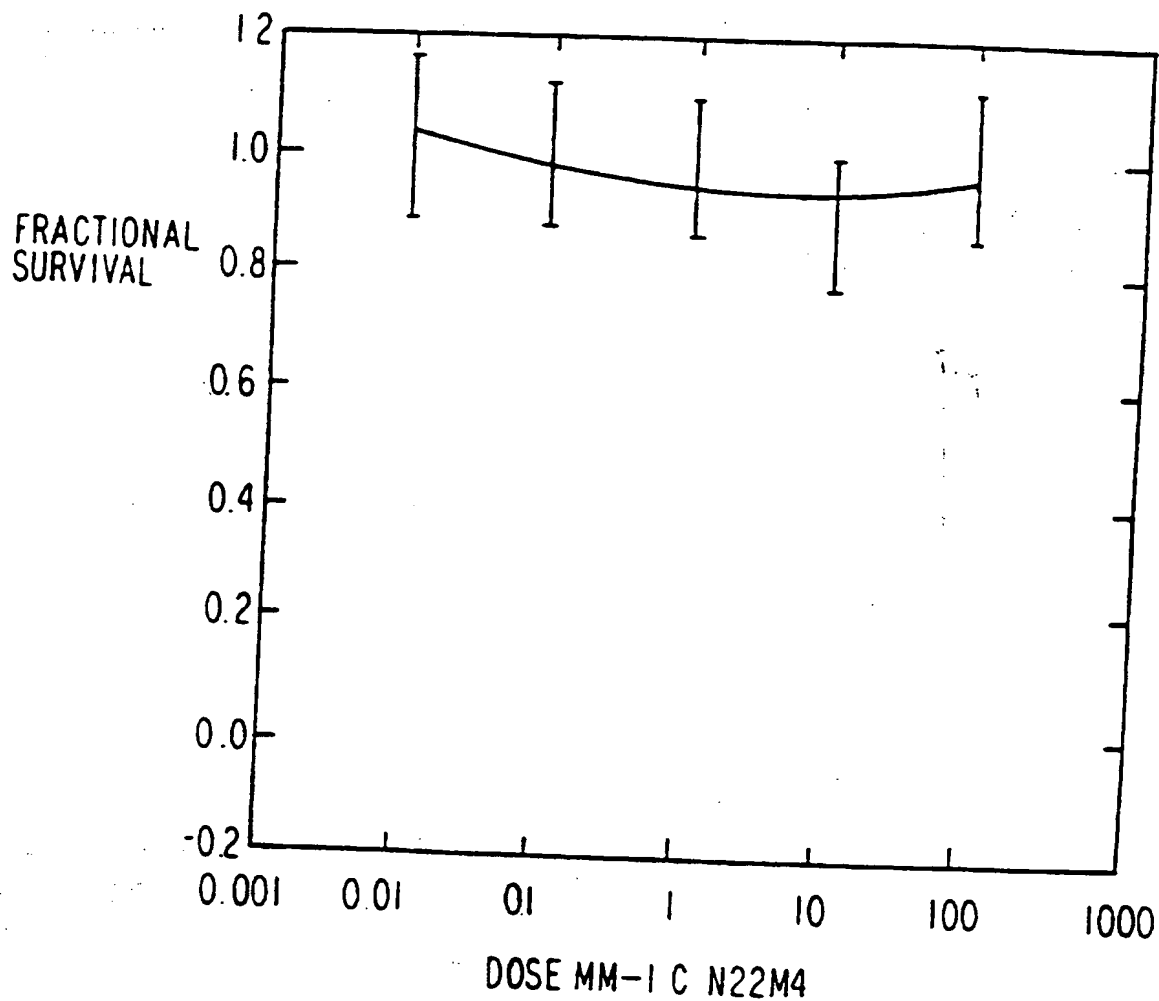
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FIG. 13B



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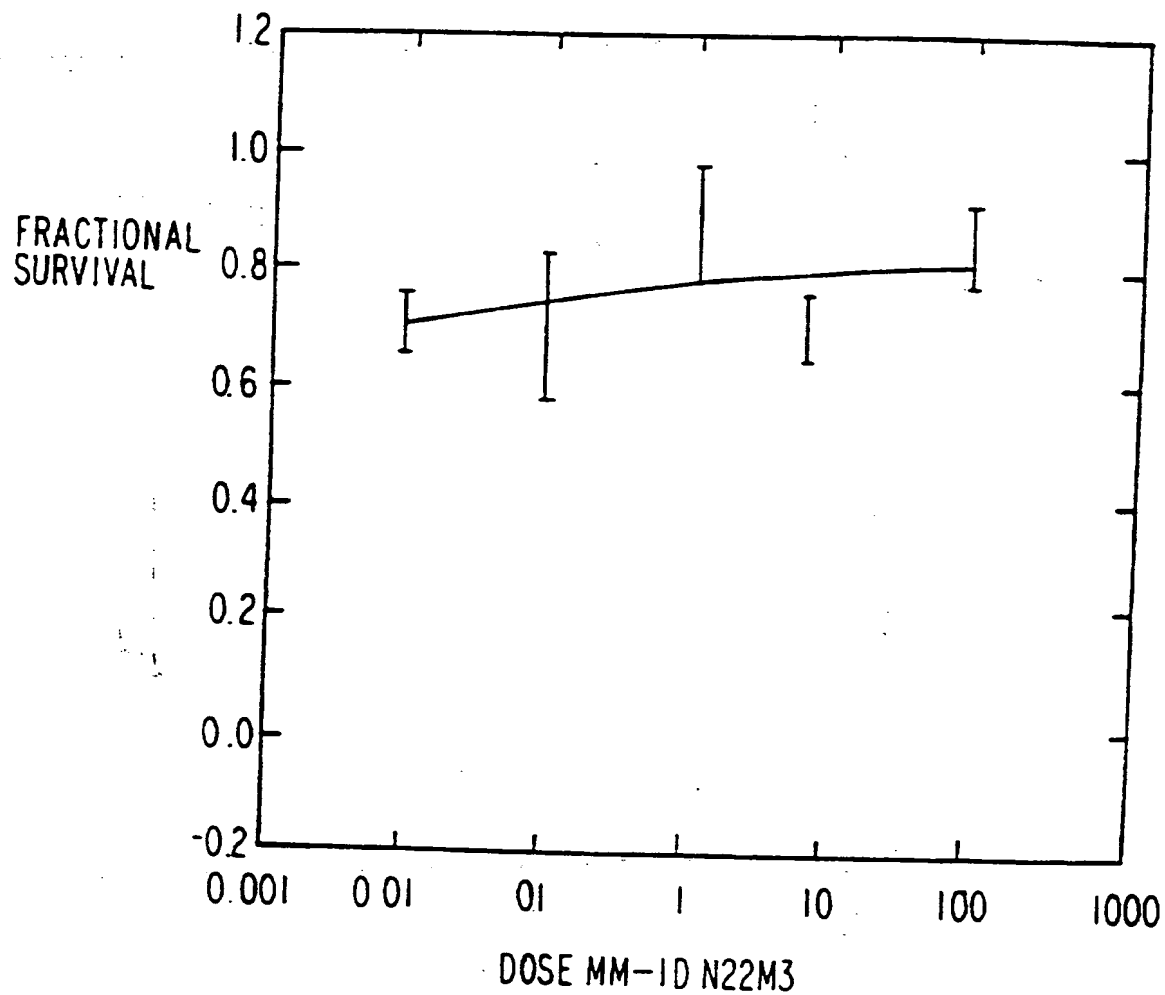
FIG. 13C



SUBSTITUTE SHEET (RULE 26)

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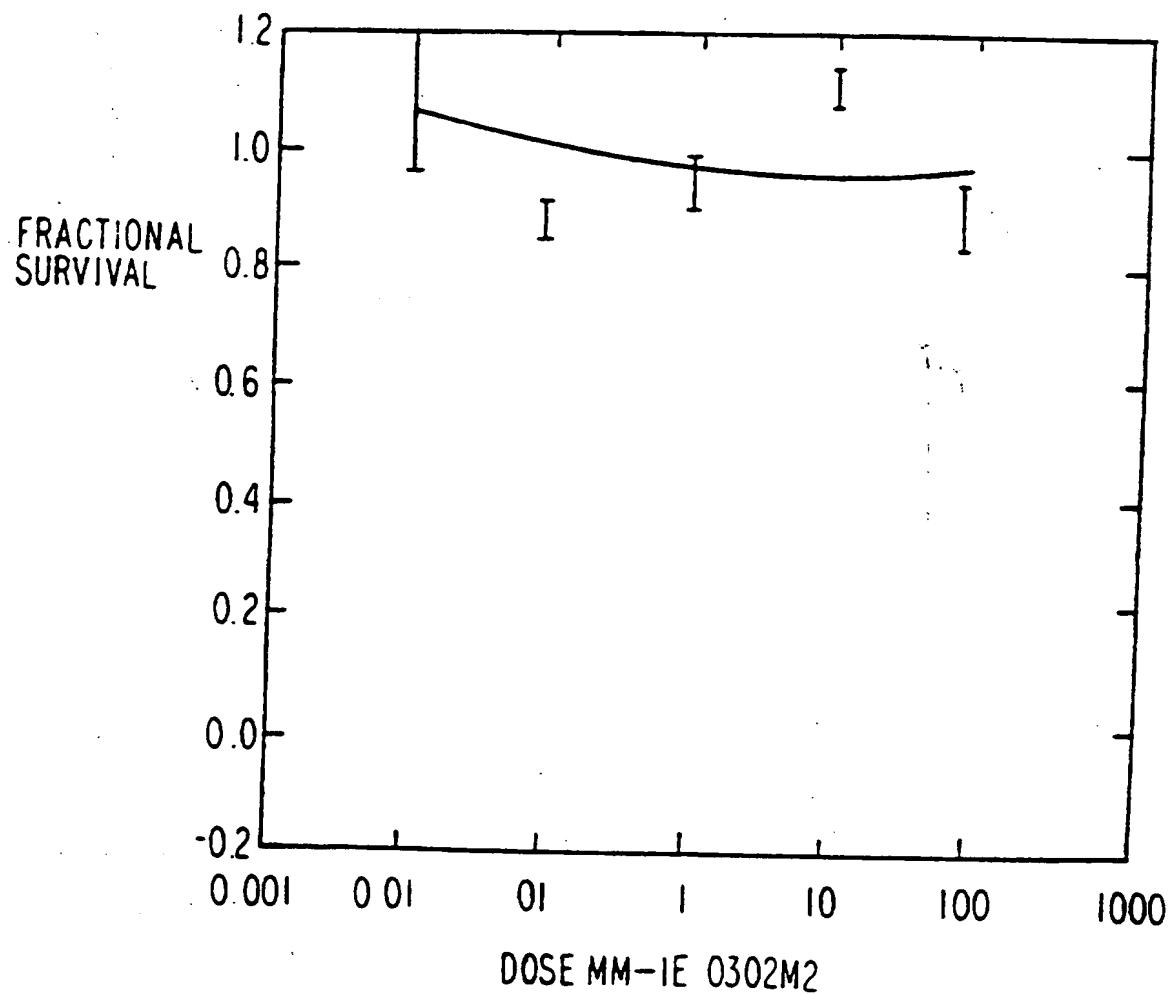
FIG. 13D





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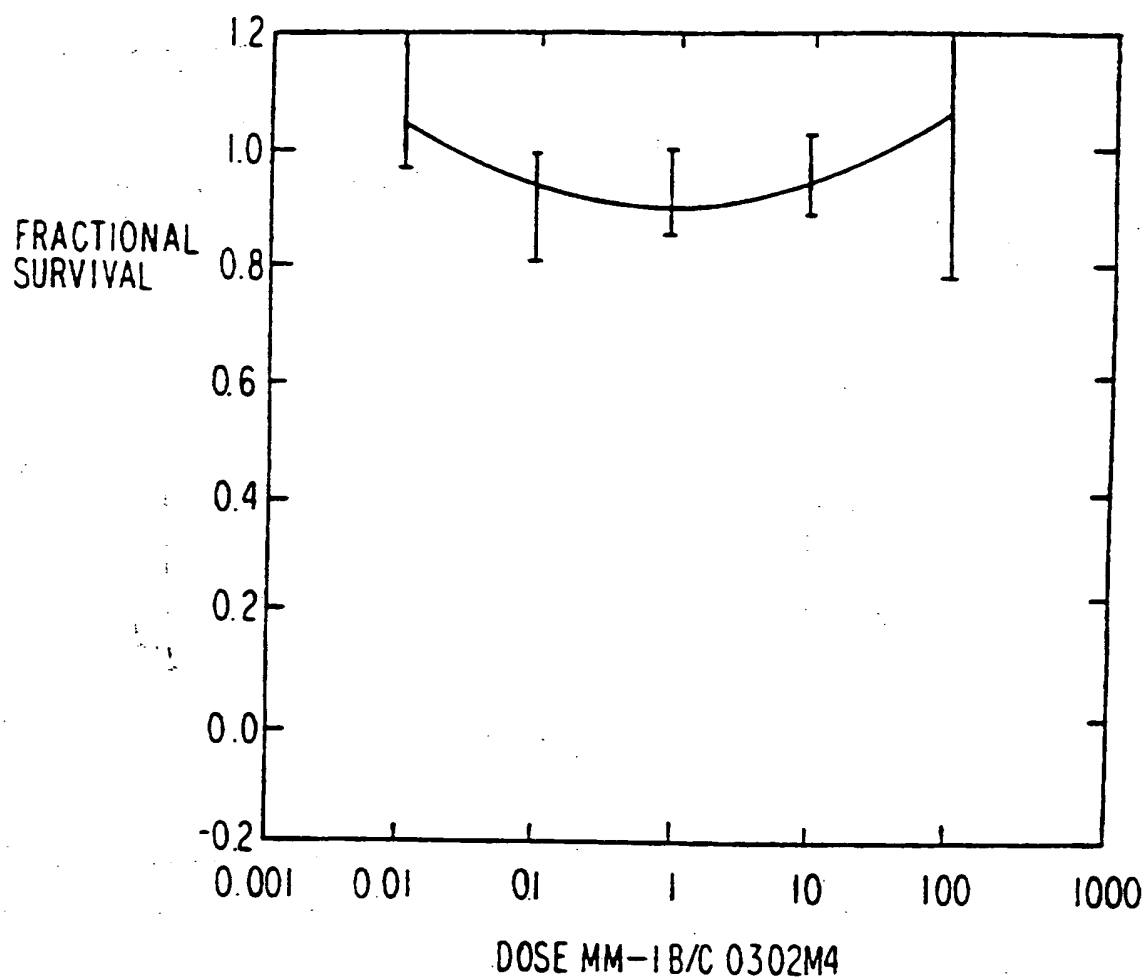
FIG. 13E



SUBSTITUTE SHEET (RULE 26)

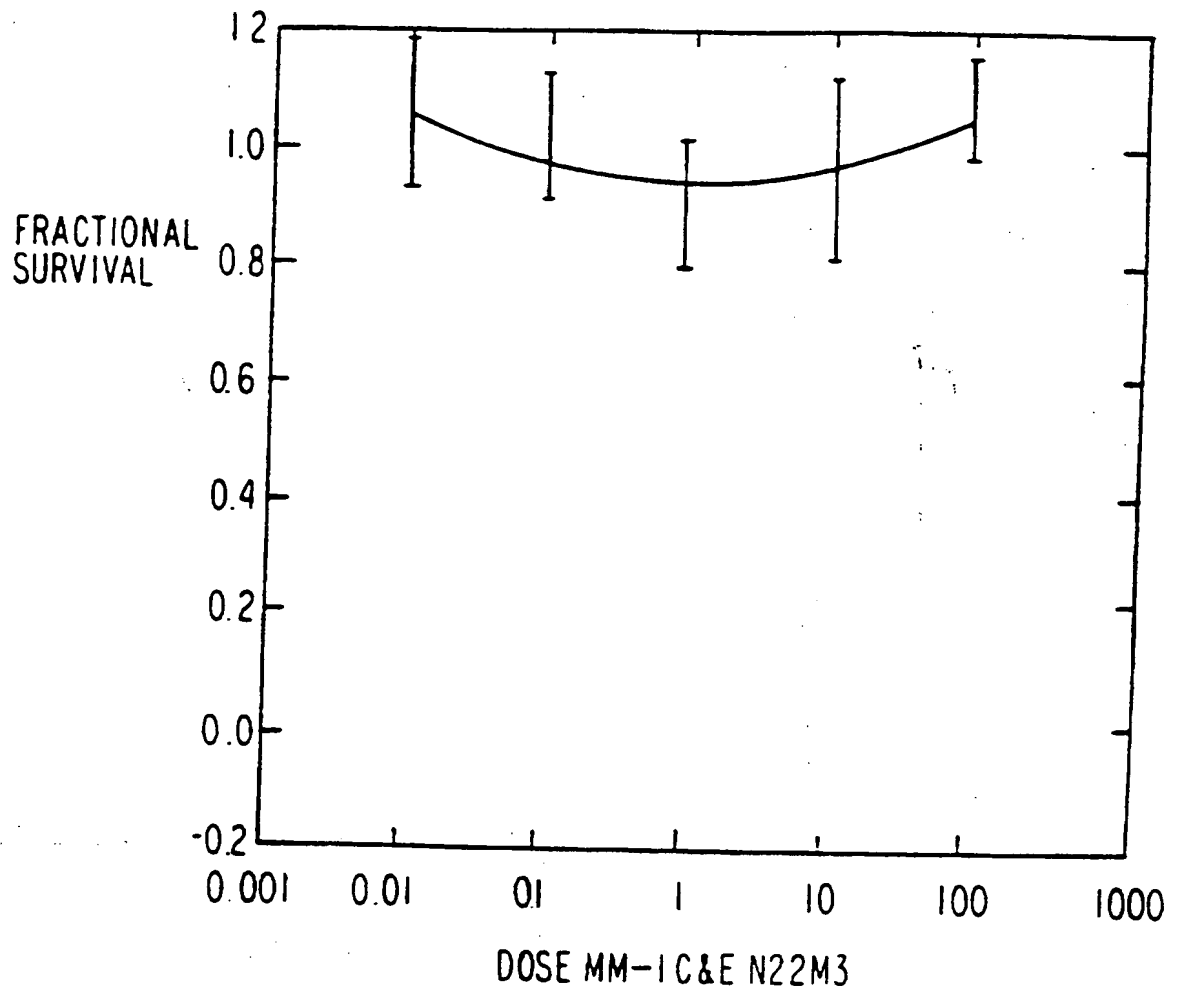
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FIG. 13F



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FIG. 13G



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FIG. 13H

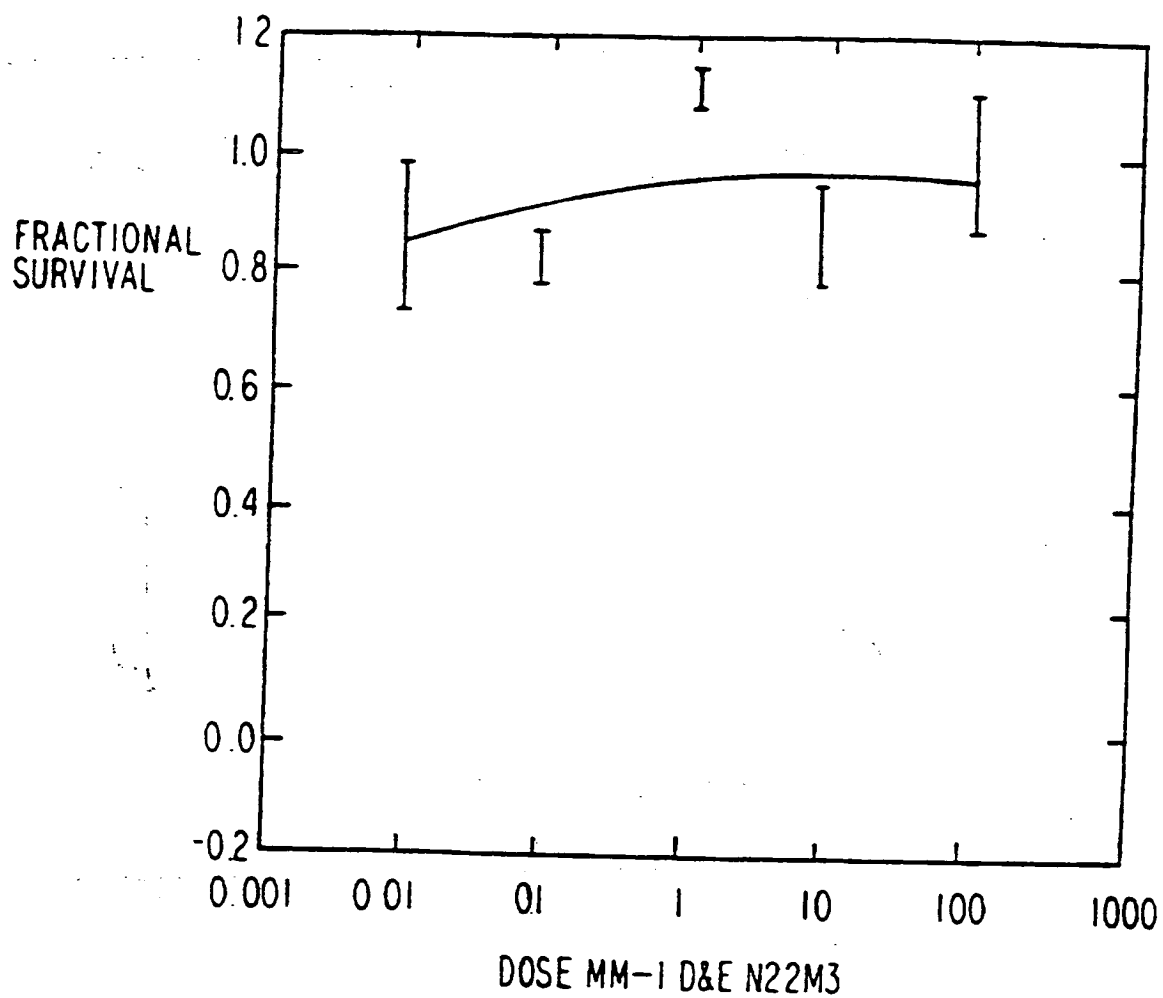
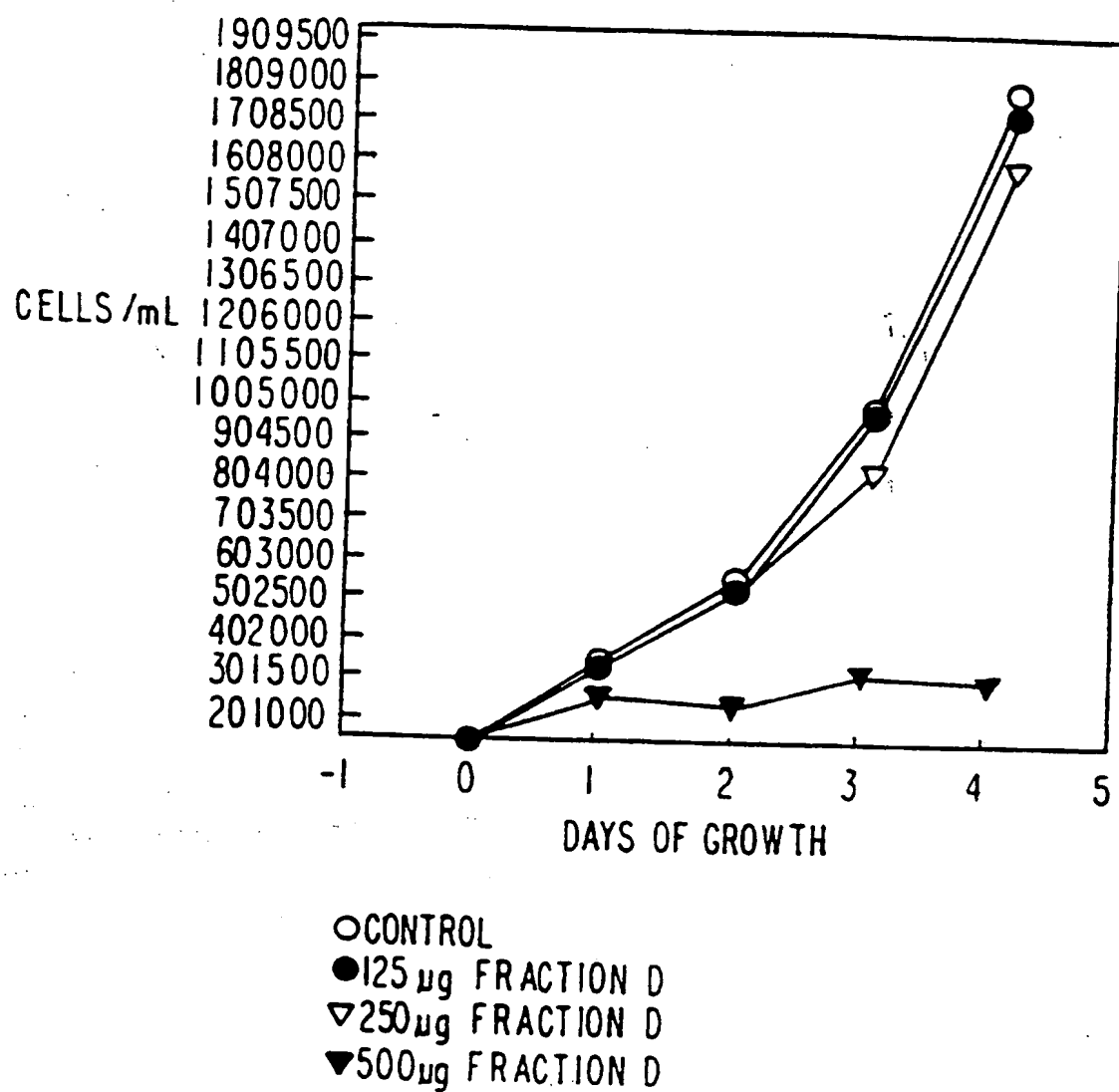


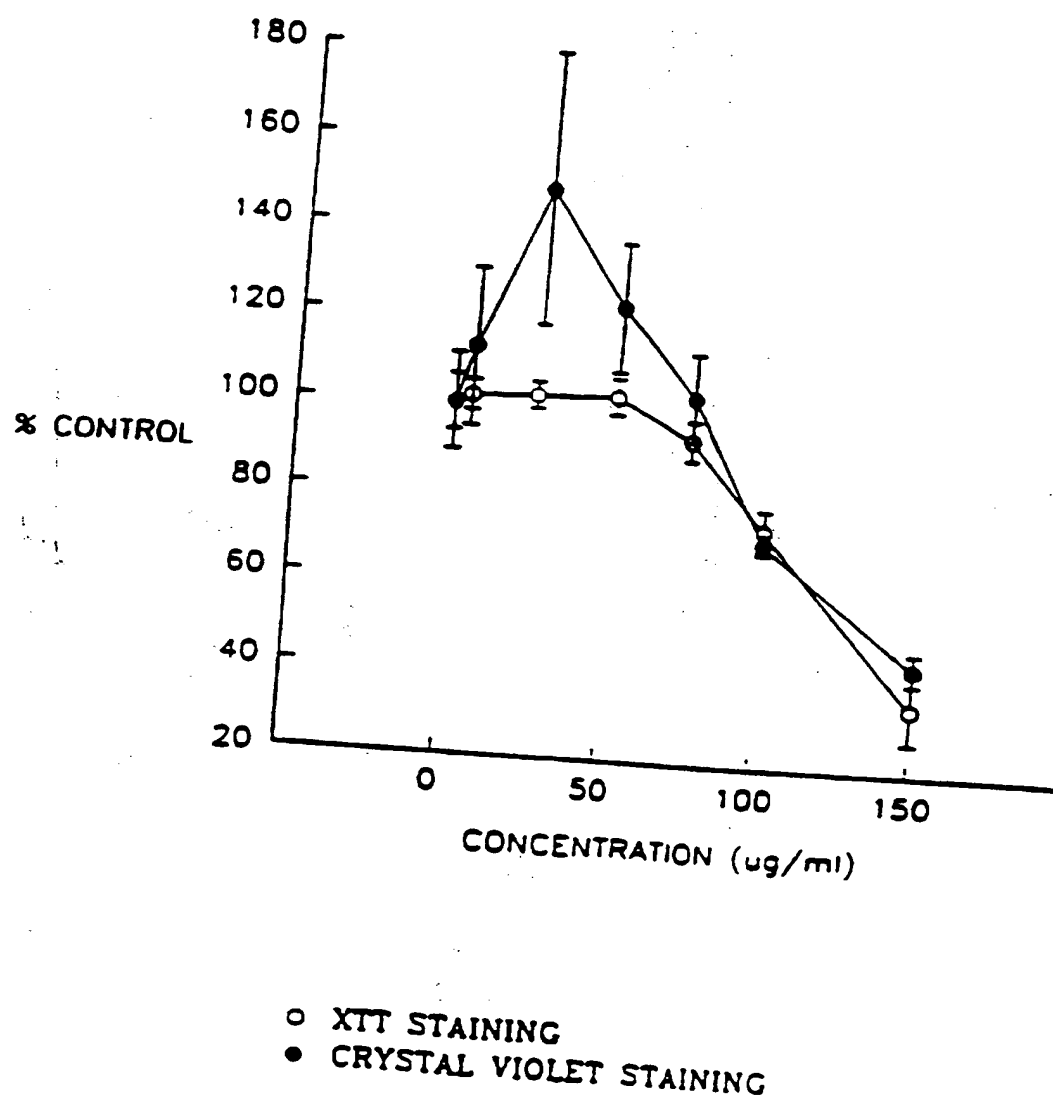
FIG. 14



SUBSTITUTE SHEET (RULE 26)

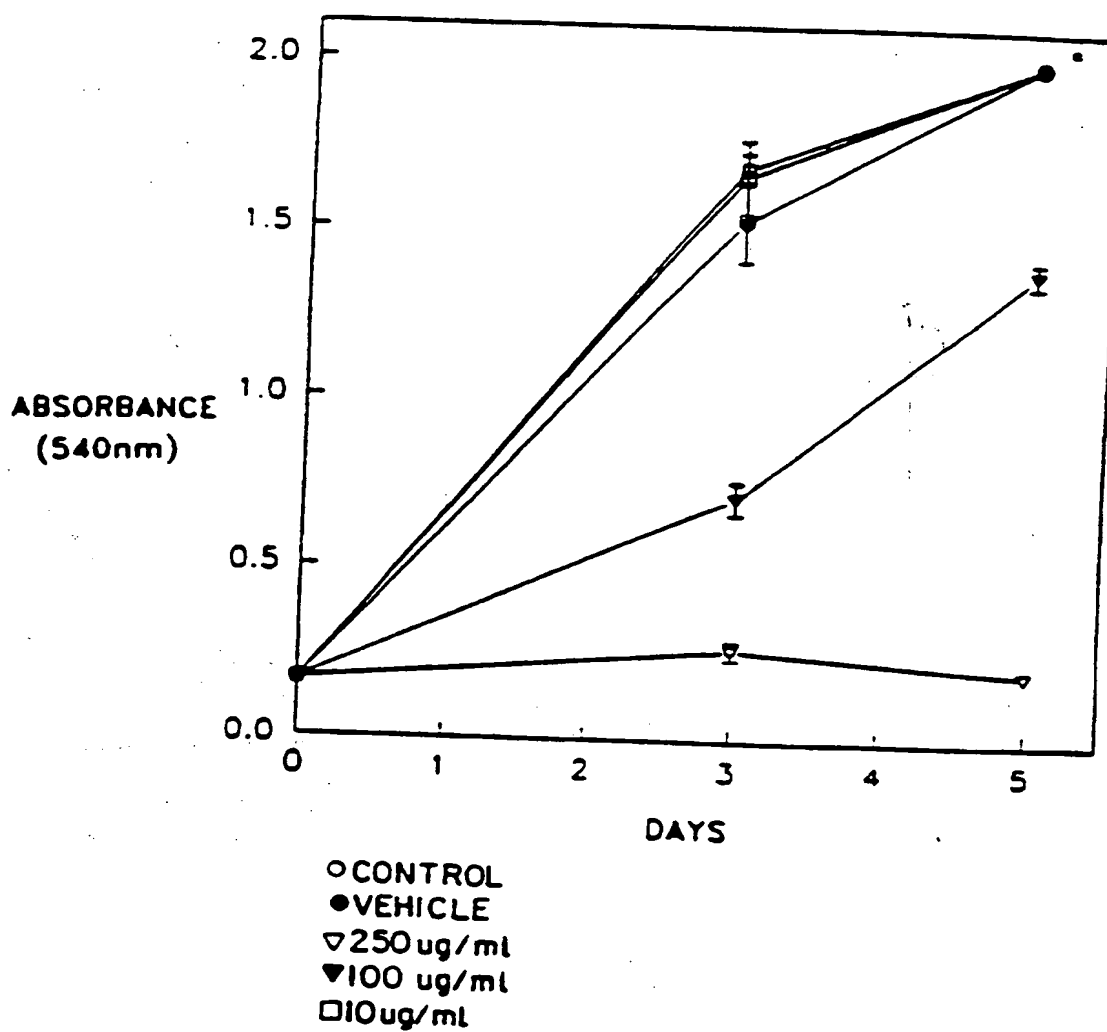
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FIG. 15A



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FIG. 15B

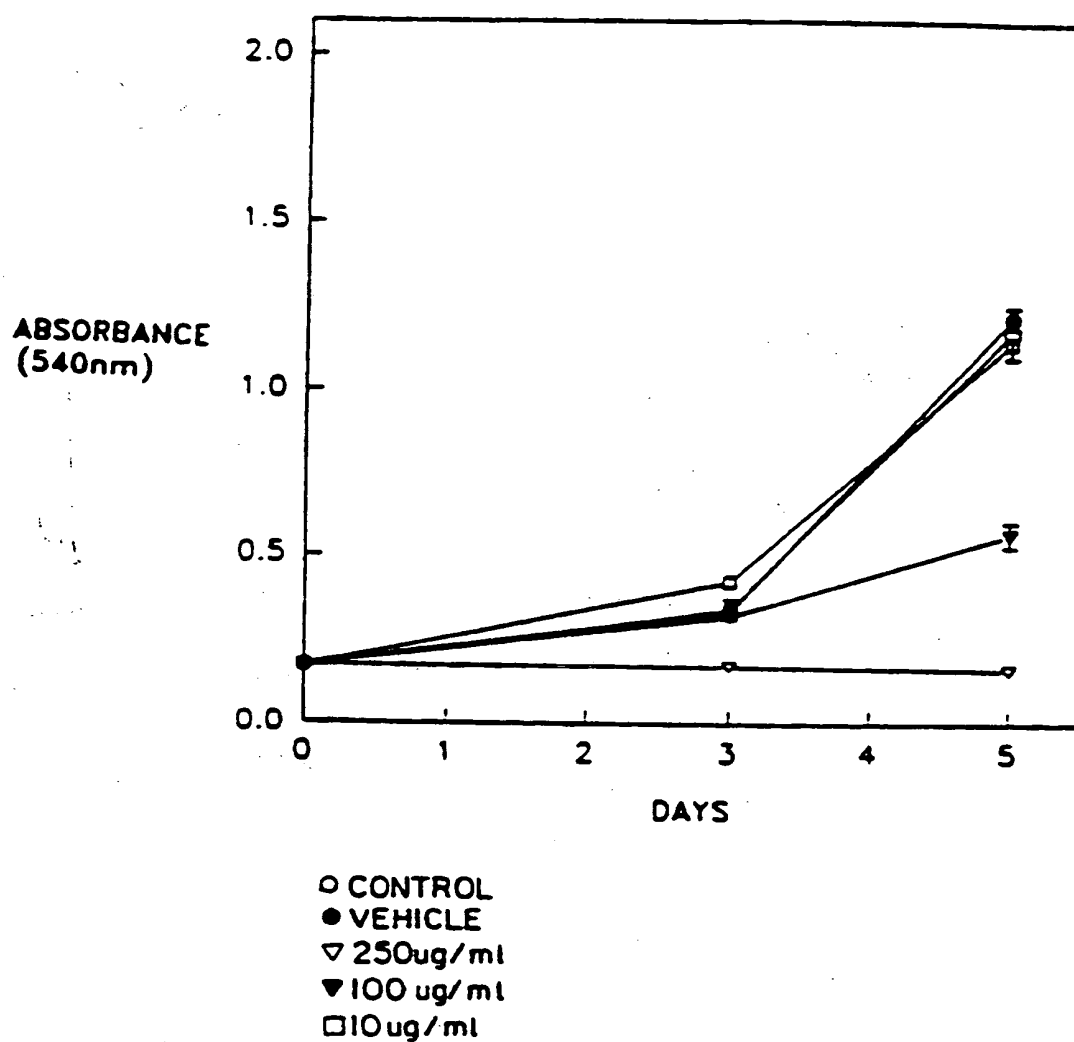


\* NOTE: ABSORBANCE OF 2.0 INDICATES THE MAXIMUM ABSORBANCE OF THE PLATE READER. IT IS NOT REPRESENTATIVE OF CELL NUMBER.

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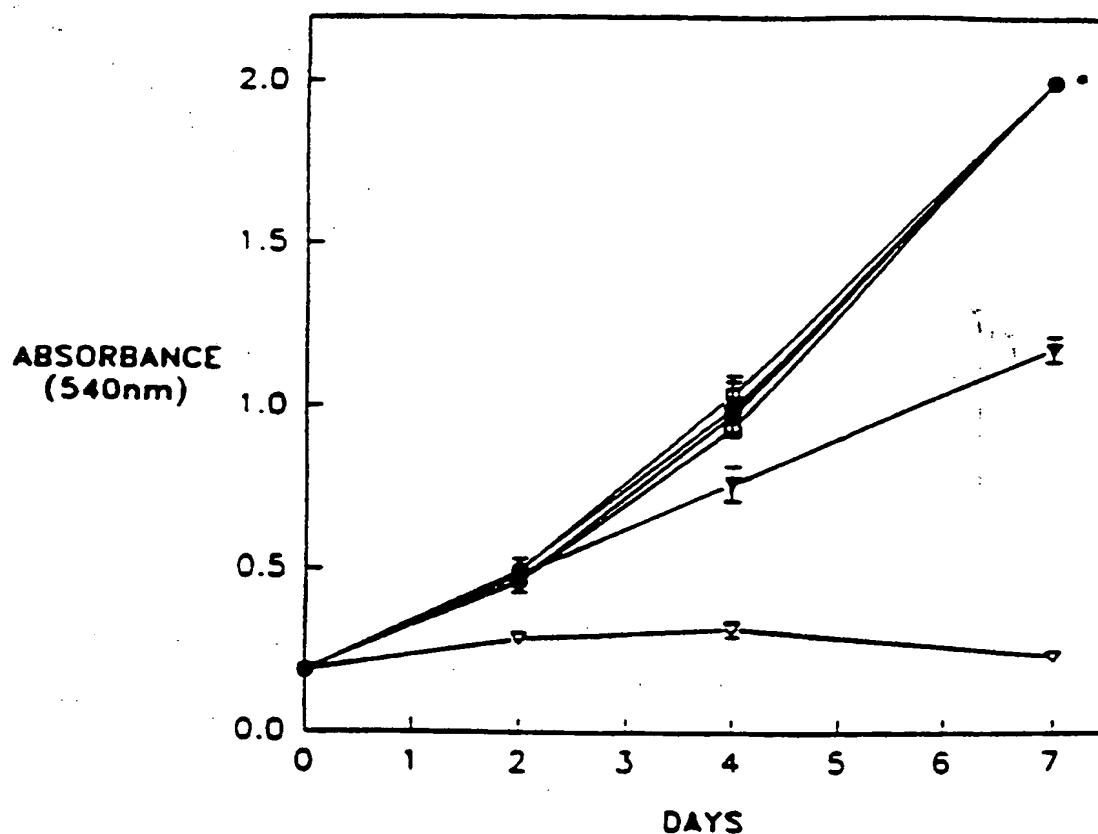
FIG. 15C





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FIG. 15D



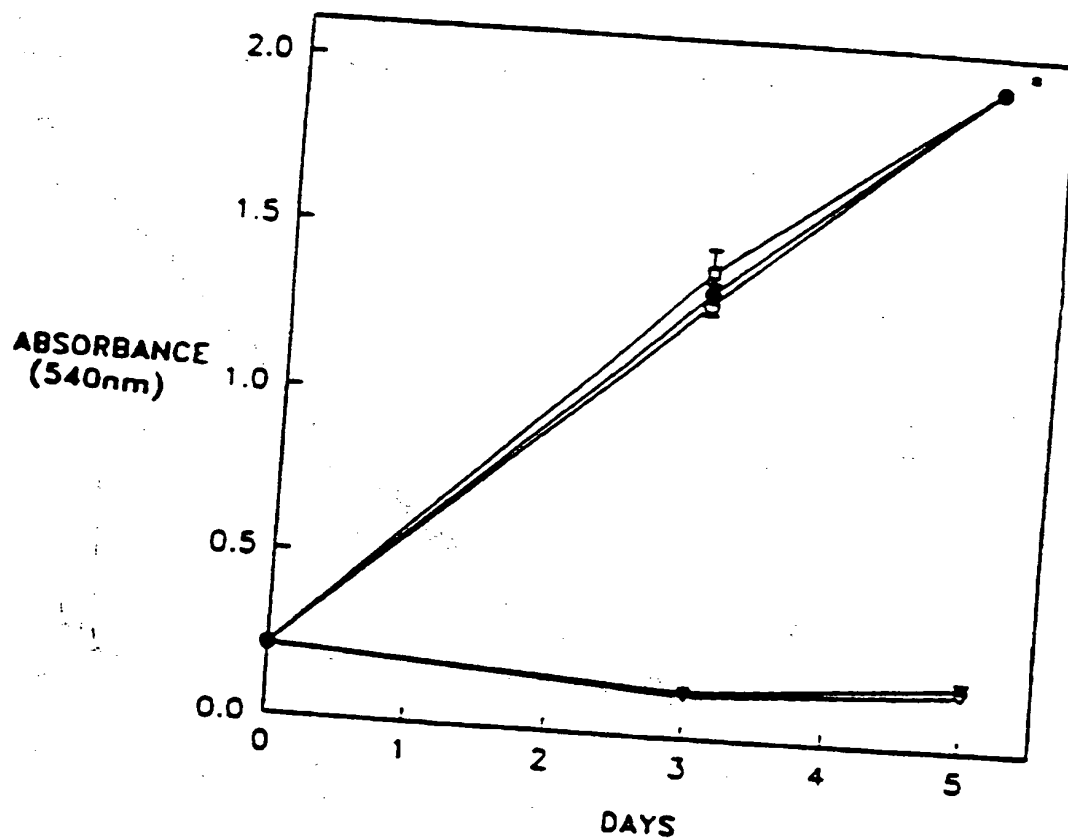
○ CONTROL  
● VEHICLE CONTROL  
▽ 250ug/ml  
▼ 100ug/ml  
□ 10ug/ml  
■ 1ug/ml

► NOTE: ABSORBANCE OF 2.0 INDICATES THE MAXIMUM ABSORBANCE OF THE PLATE READER. IT IS NOT REPRESENTATIVE OF CELL NUMBER.

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FIG. 15E

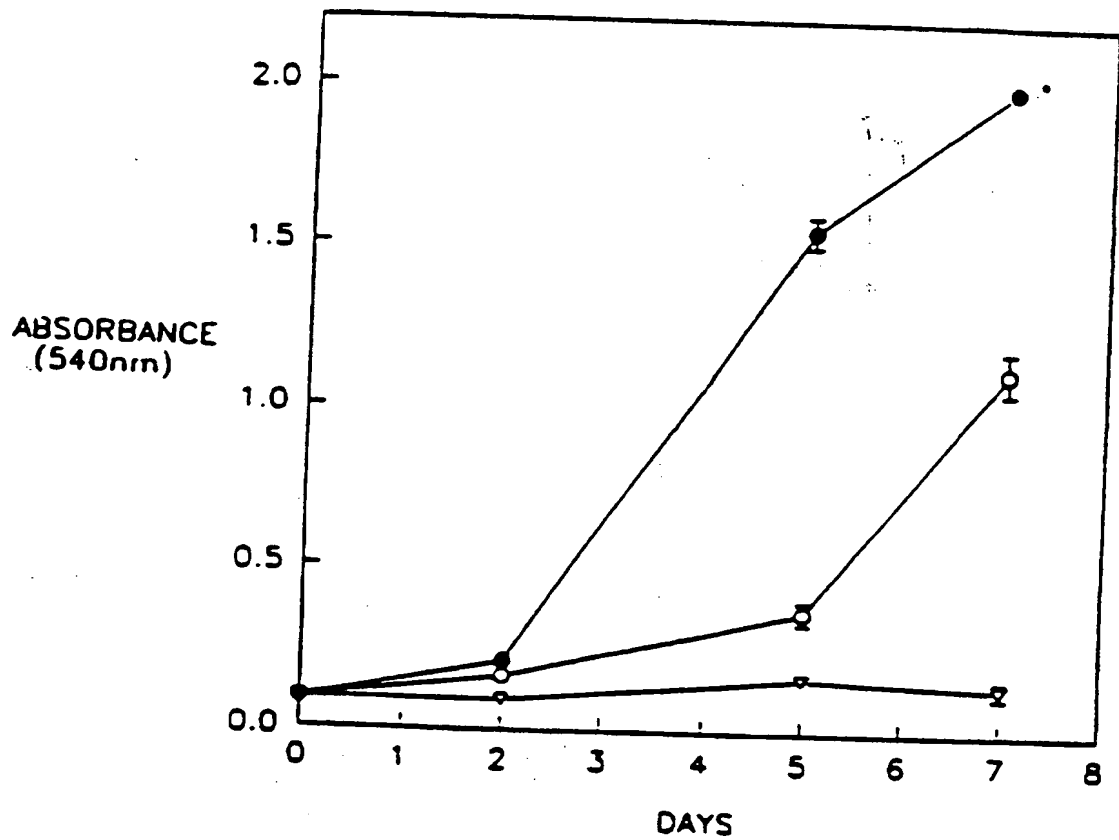


○ CONTROL  
● VEHICLE  
▽ 250 ug/ml  
▼ 100 ug/ml  
□ 10 ug/ml

\* NOTE: ABSORBANCE OF 2.0 INDICATES THE MAXIMUM ABSORBANCE OF THE PLATE READER. IT IS NOT REPRESENTATIVE OF CELL NUMBER.

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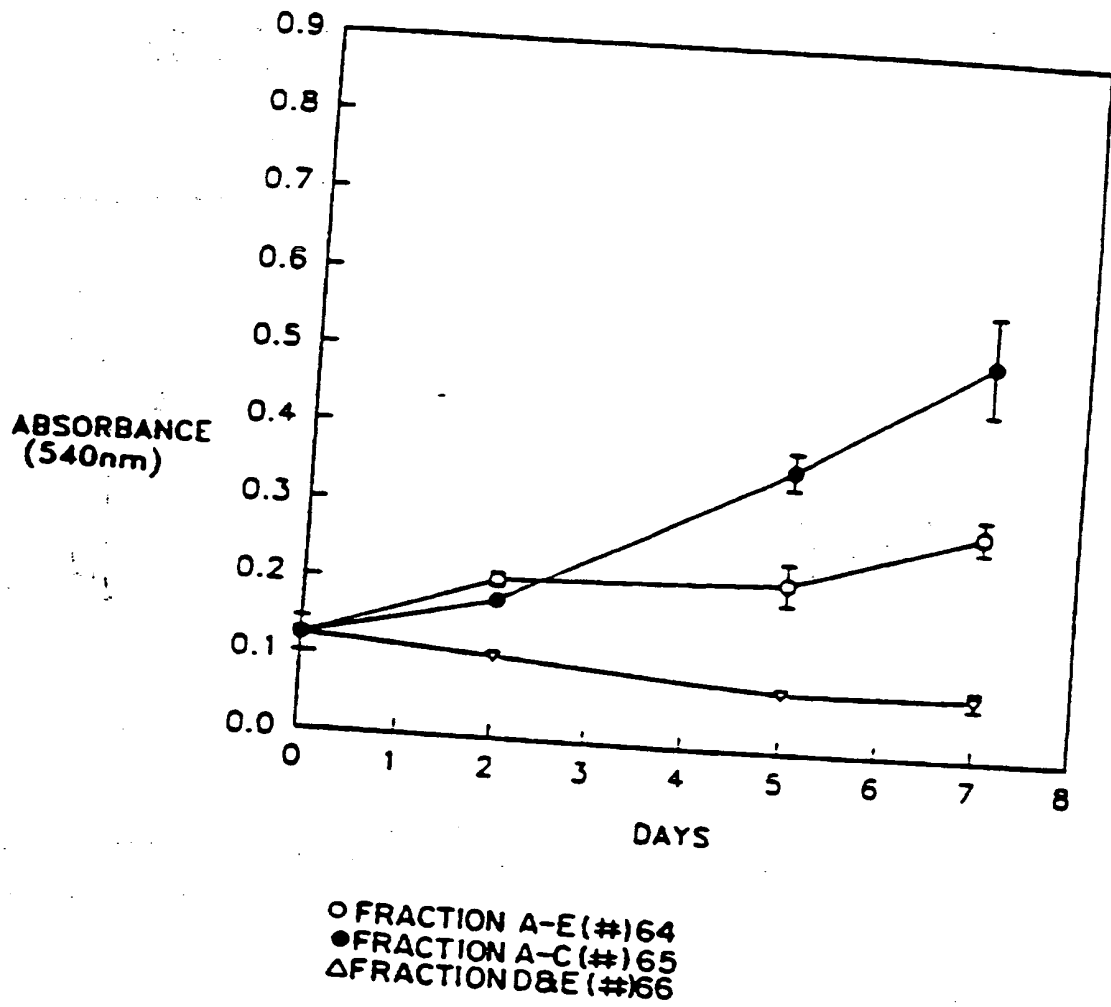
FIG. 15F



\* NOTE: ABSORBANCE OF 2.0 INDICATES THE MAXIMUM  
ABSORBANCE OF THE PLATE READER. IT IS NOT  
REPRESENTATIVE OF CELL NUMBER.

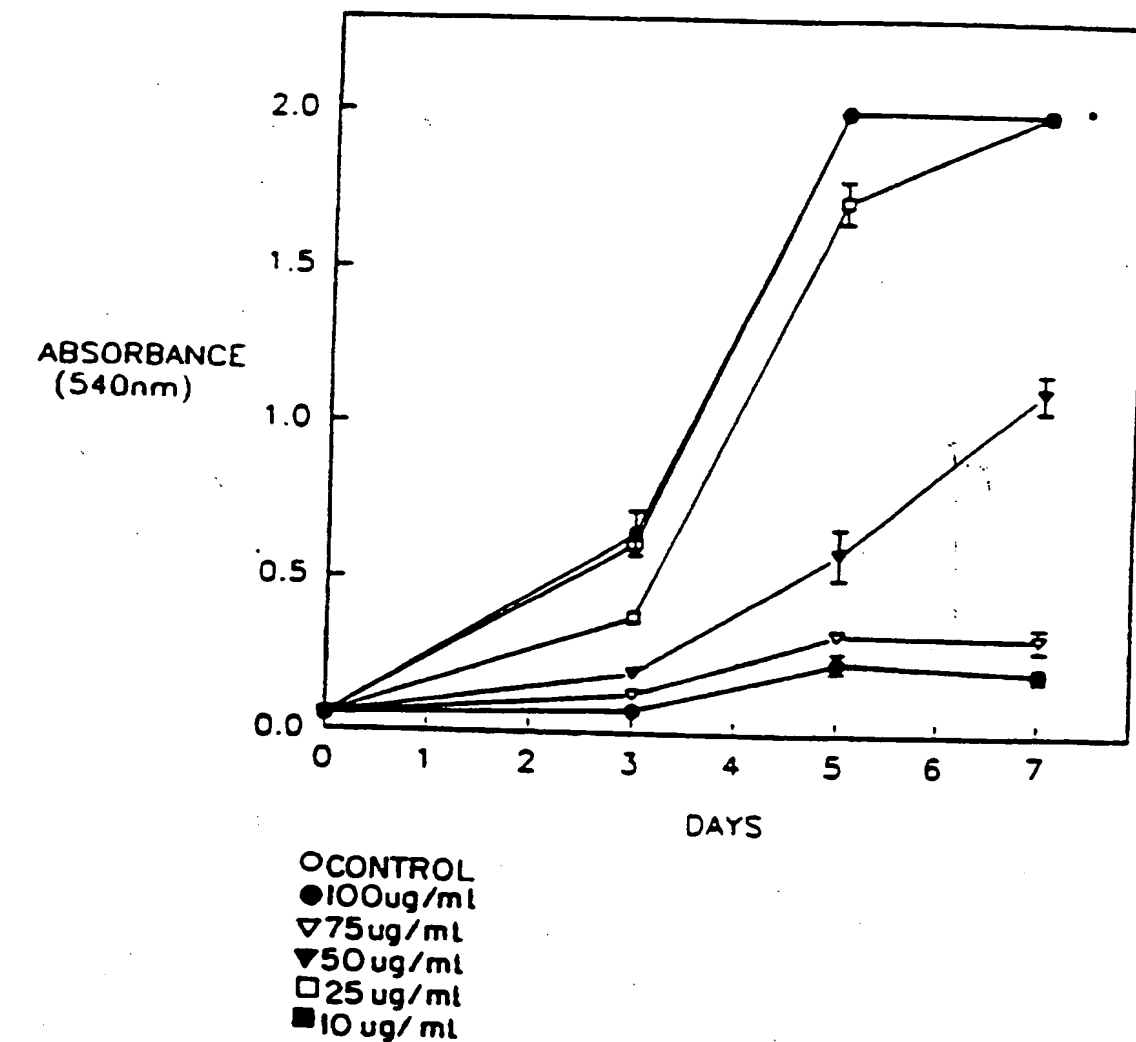
SUBSTITUTE SHEET (RULE 26)

FIG. 15G



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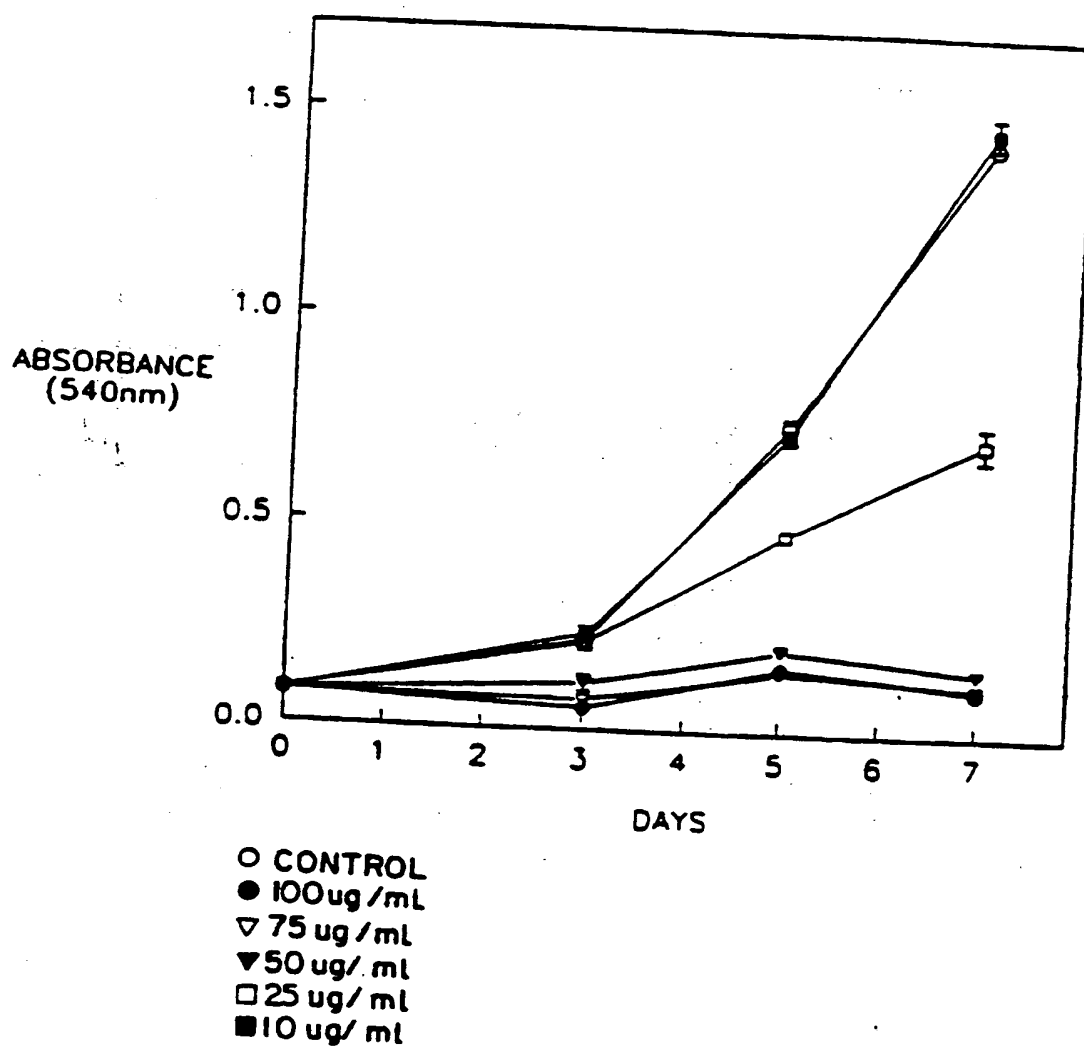
FIG. 15H



\*NOTE: ABSORBANCE OF 2.0 INDICATES THE MAXIMUM ABSORBANCE OF THE PLATE READER. IT IS NOT REPRESENTATIVE OF CELL NUMBER.

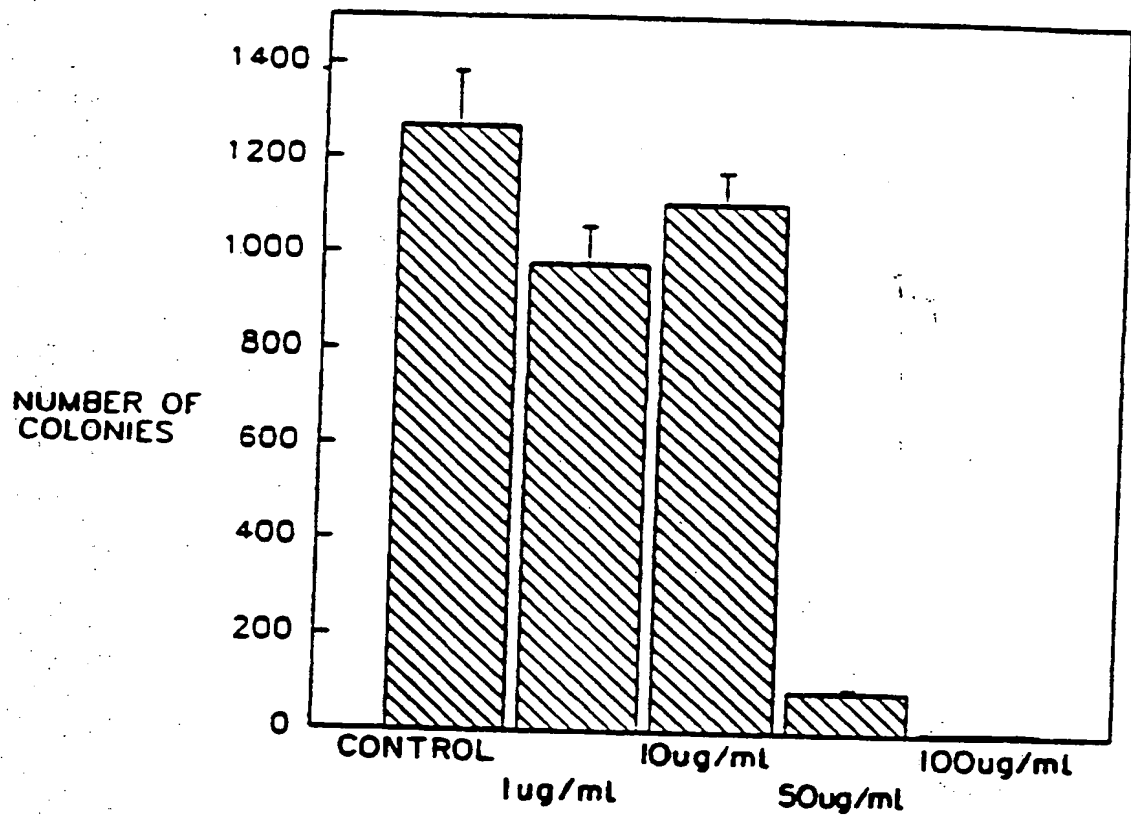
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FIG. 15I



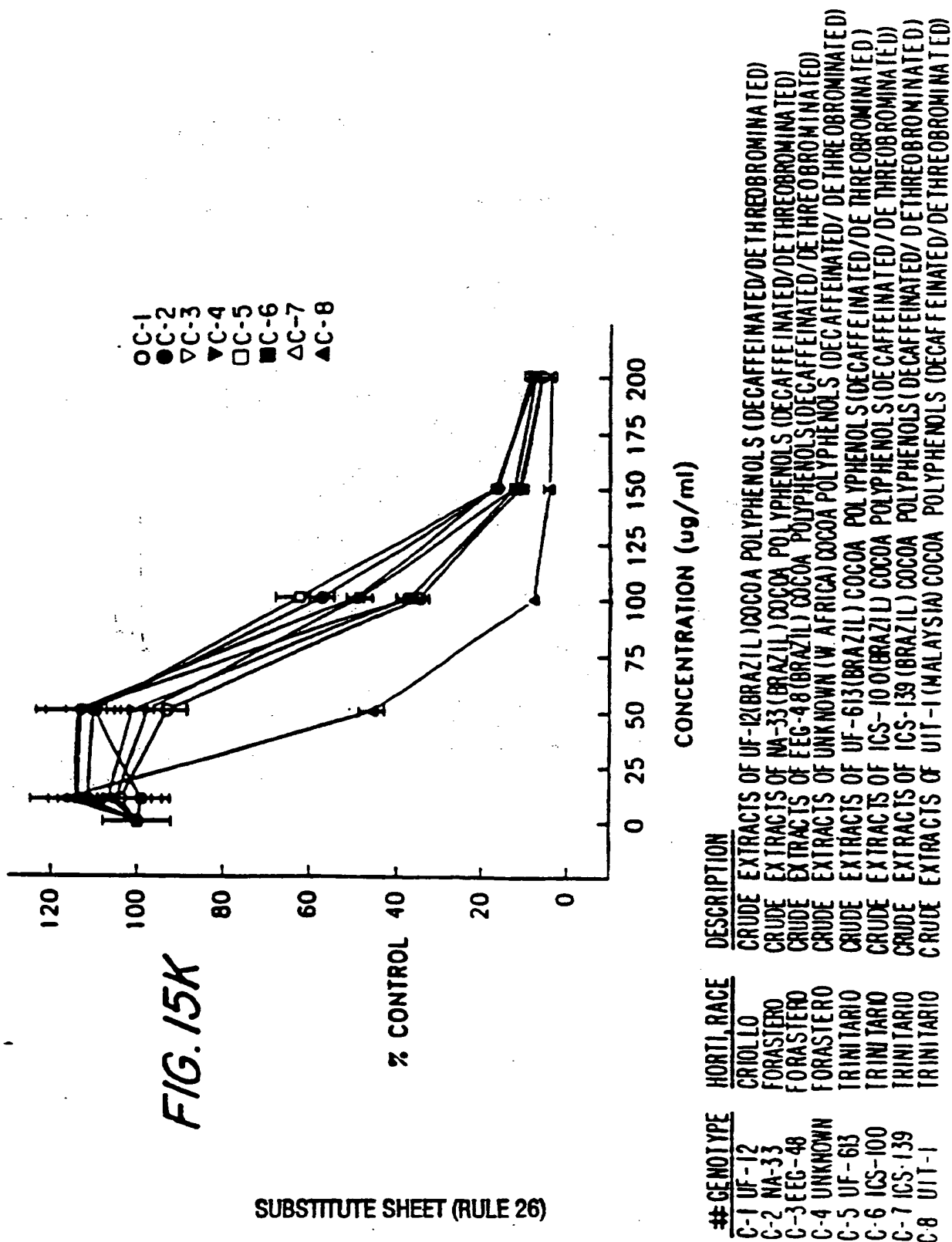
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FIG. 15J



SUBSTITUTE SHEET (RULE 26)

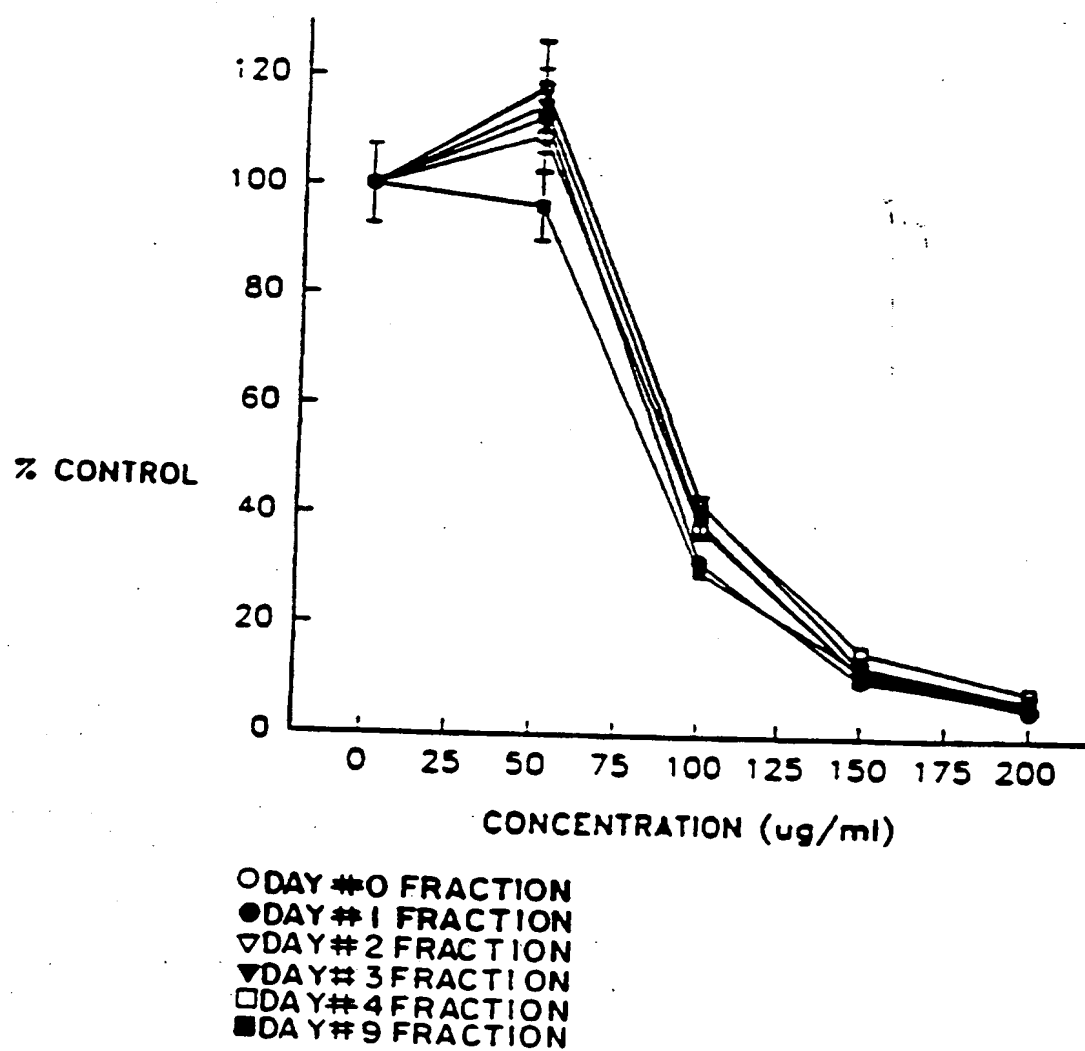
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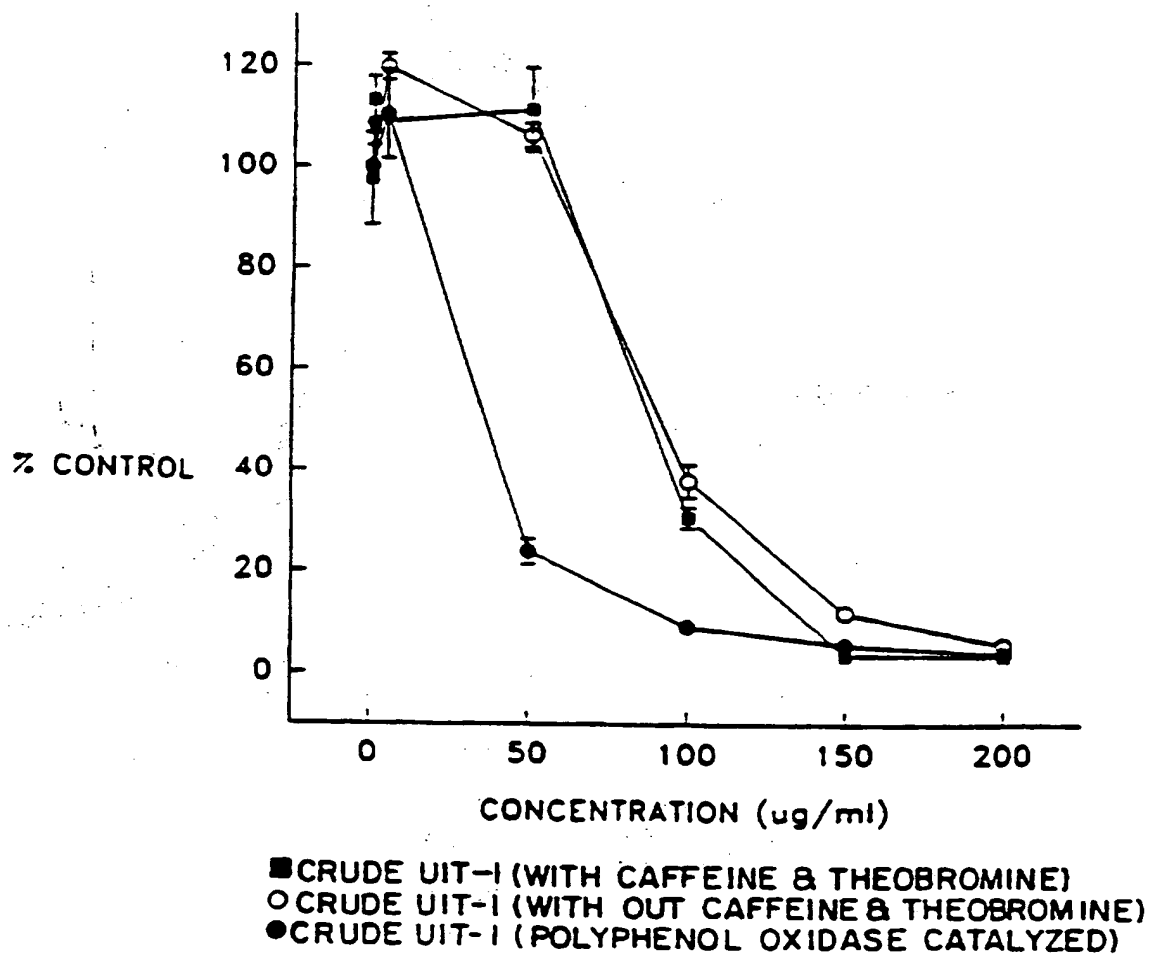
FIG. 15L



SUBSTITUTE SHEET (RULE 26)

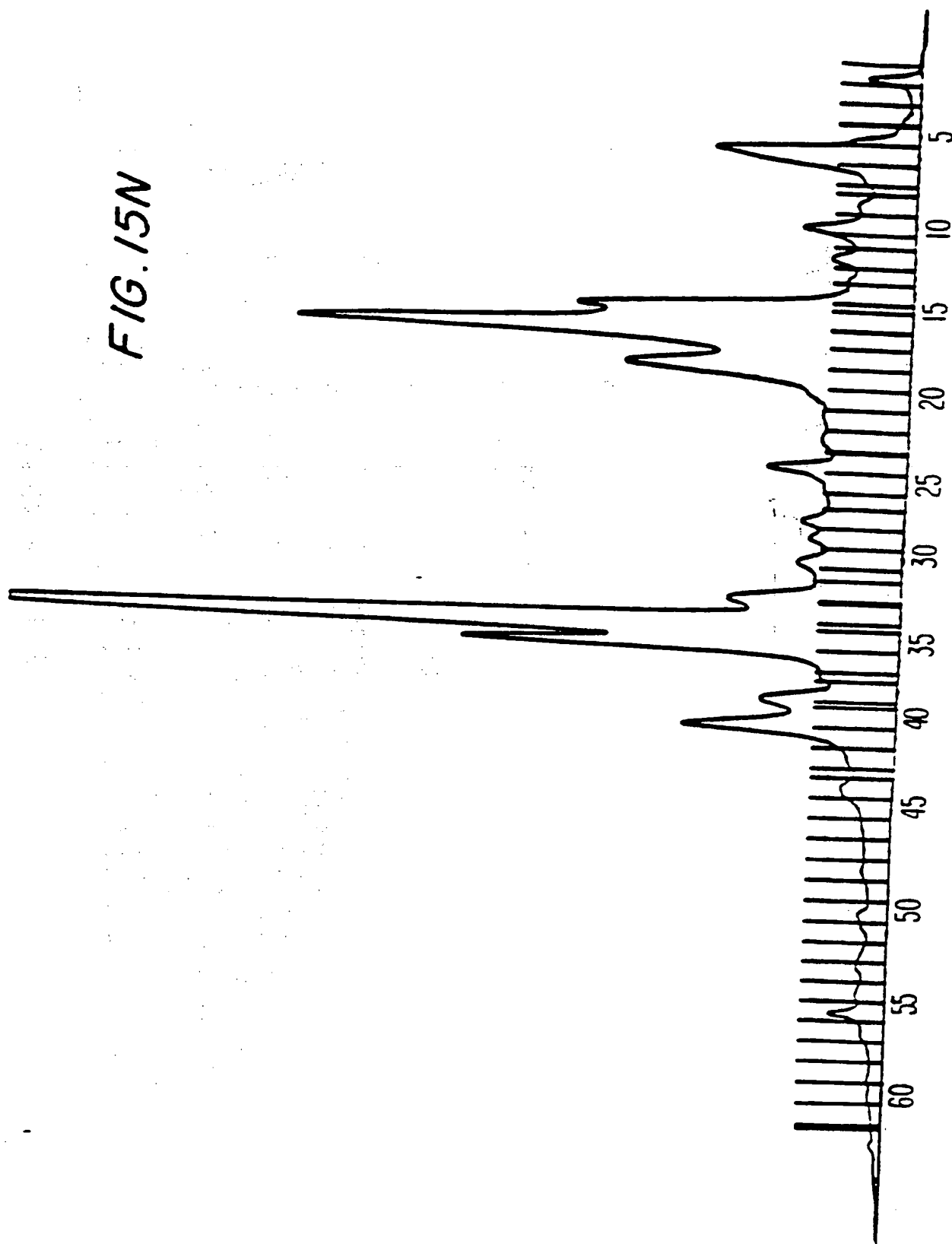
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FIG. 15M



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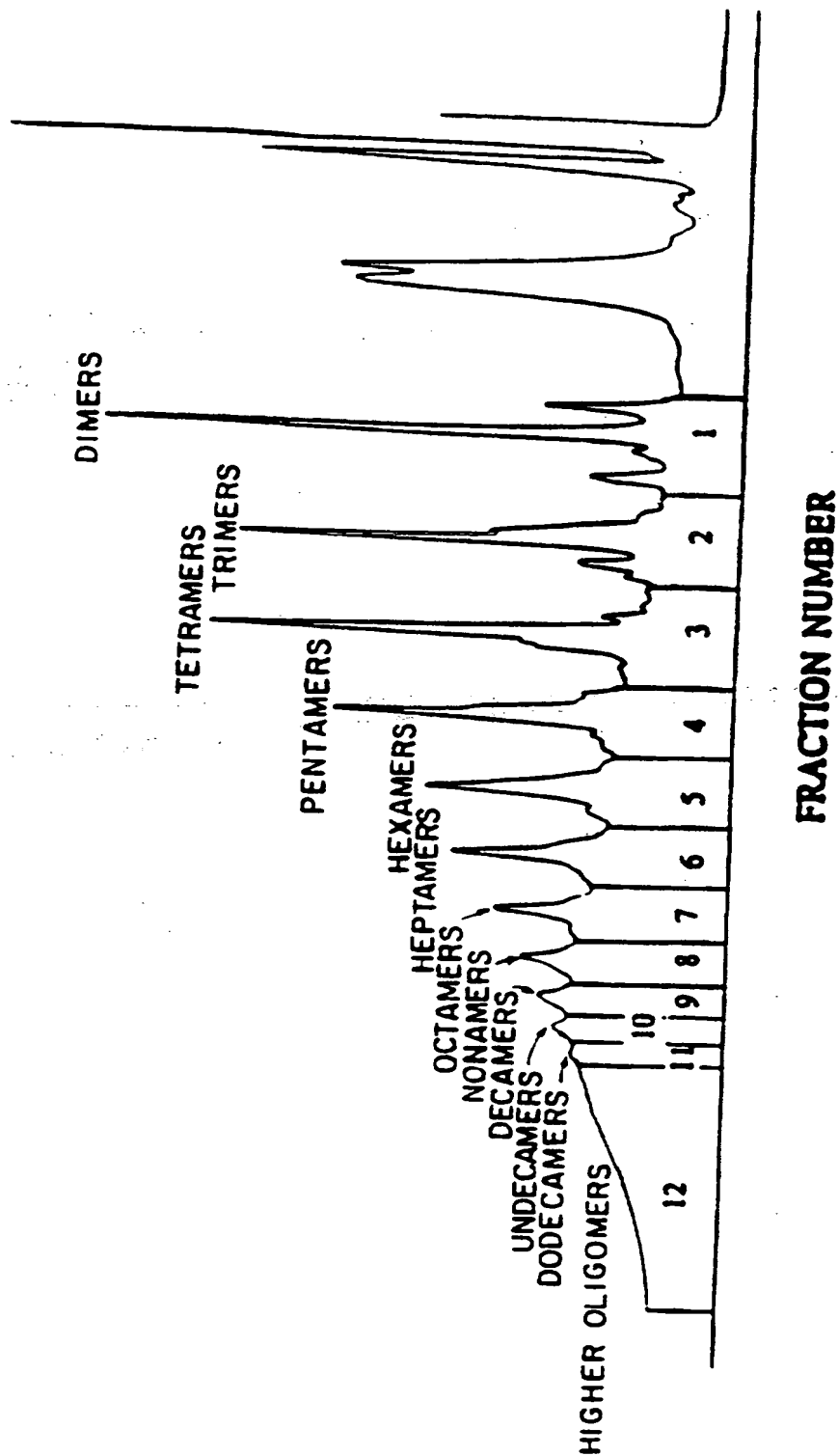
FIG. 15N



SUBSTITUTE SHEET (RULE 26)

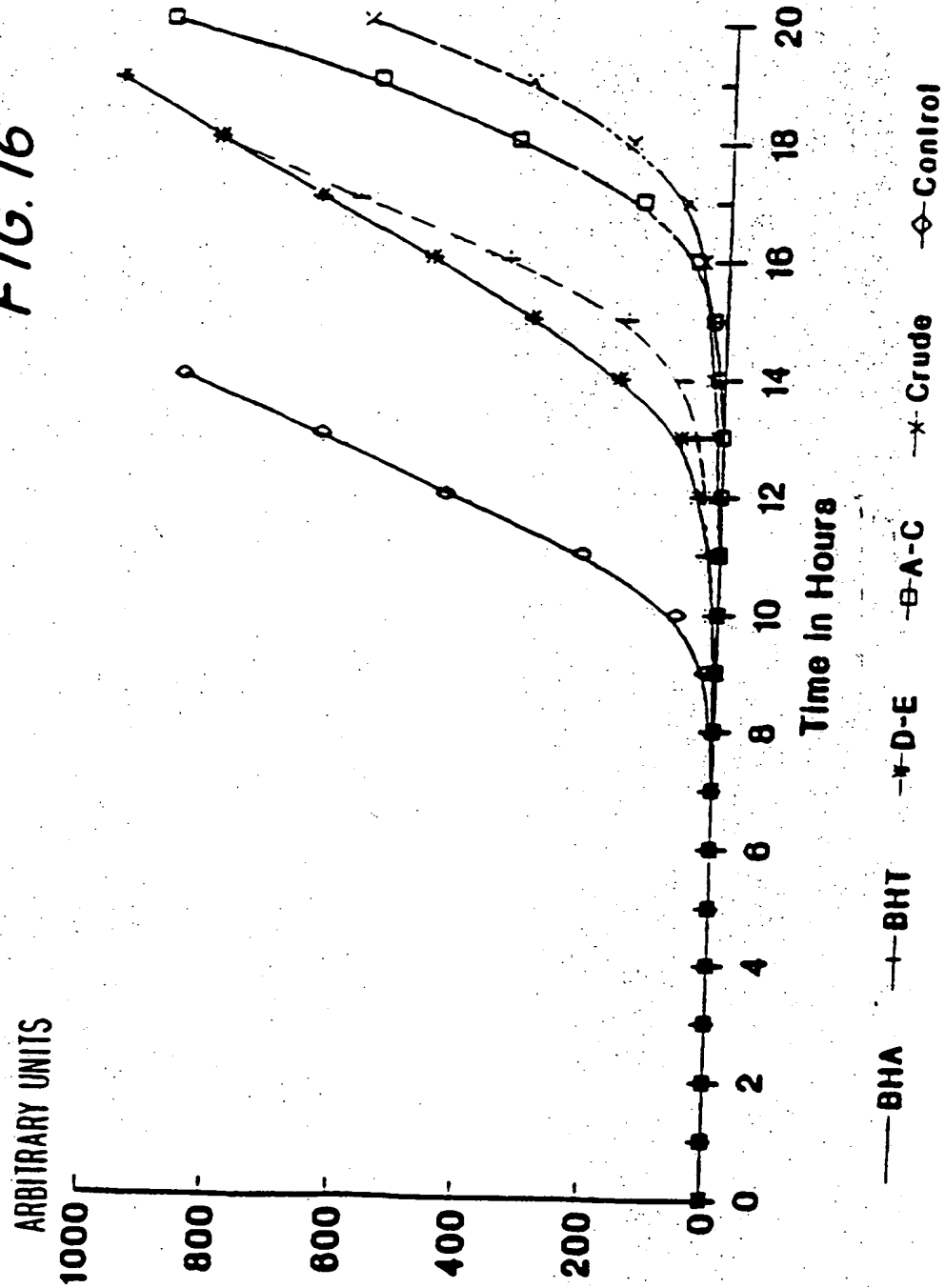
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FIG. 150



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FIG. 16



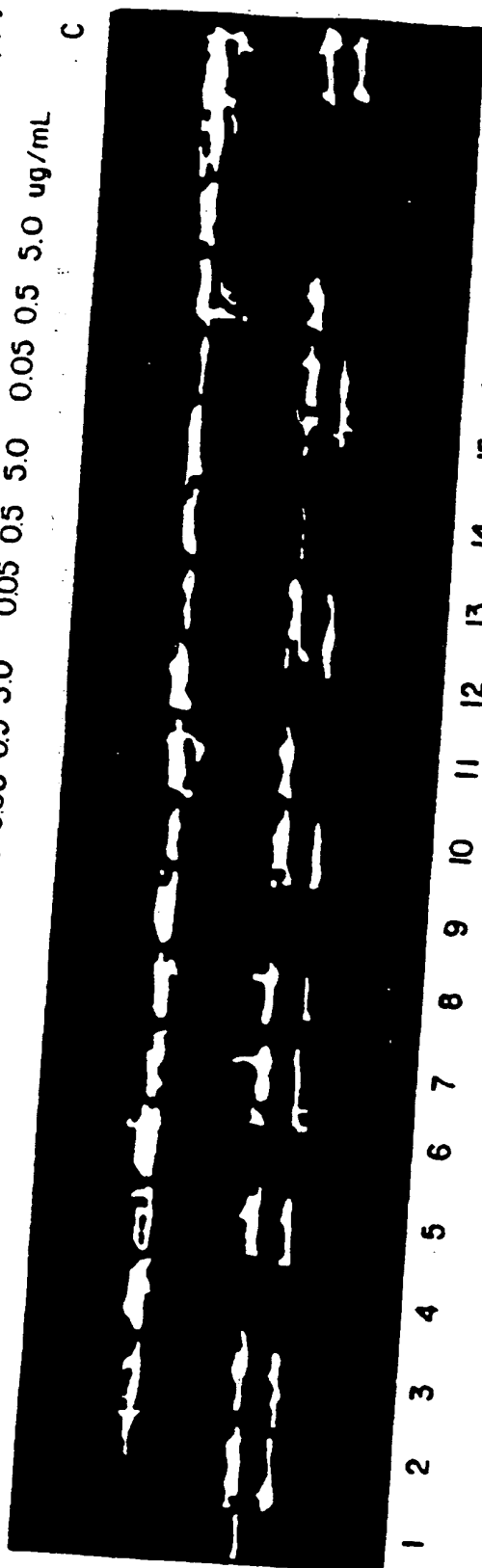
SUBSTITUTE SHEET (RULE 26)

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FIG. 17

M	C	FRACTION A	FRACTION B	FRACTION D	FRACTION E	FRACTION D	FRACTION E
0.5	5.0	0.5	5.0	0.05	0.5	0.05	0.5
0.05	0.5	0.05	0.5	0.05	0.5	0.05	0.5

ug/mL



LANES 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

LANE 1 CONTAINS 0.5  $\mu$ g OF MARKER (M) MONOMER-LENGTH KINETOPLAST DNA CIRCLES. LANES 2 AND 20 CONTAIN KINETOPLAST DNA THAT WAS INCUBATED WITH TOPOISOMERASE II IN THE PRESENCE OF 4% DMSO, BUT IN THE ABSENCE OF ANY COCOA PROCYANIDIN (CONTROL -C). LANES 3 AND 4 CONTAIN KINETOPLAST DNA THAT WAS INCUBATED WITH TOPOISOMERASE II IN THE PRESENCE OF 0.5 AND 5.0  $\mu$ g/mL COCOA PROCYANIDIN (CONTROL -C). LANES 5 AND 6 CONTAIN KINETOPLAST DNA THAT WAS INCUBATED WITH TOPOISOMERASE II IN THE PRESENCE OF 0.5 AND 5.0  $\mu$ g/mL COCOA PROCYANIDIN FRACTION A. LANES 7, 8, 9, 13, 14 AND 15 ARE REPLICATES OF KINETOPLAST DNA THAT WAS INCUBATED WITH TOPOISOMERASE II IN THE PRESENCE OF 0.05, 0.5 AND 5.0  $\mu$ g/mL COCOA PROCYANIDIN FRACTION B. LANES 10, 11, 12, 16, 17, AND 18 ARE REPLICATES OF KINETOPLAST DNA THAT WAS INCUBATED WITH TOPOISOMERASE II IN THE PRESENCE OF 0.05, 0.5 AND 5.0  $\mu$ g/mL COCOA PROCYANIDIN FRACTION D. LANE 19 IS A REPLICATE OF KINETOPLAST DNA THAT WAS INCUBATED WITH TOPOISOMERASE II IN THE PRESENCE OF 5.0  $\mu$ g/mL COCOA PROCYANIDIN FRACTION E.

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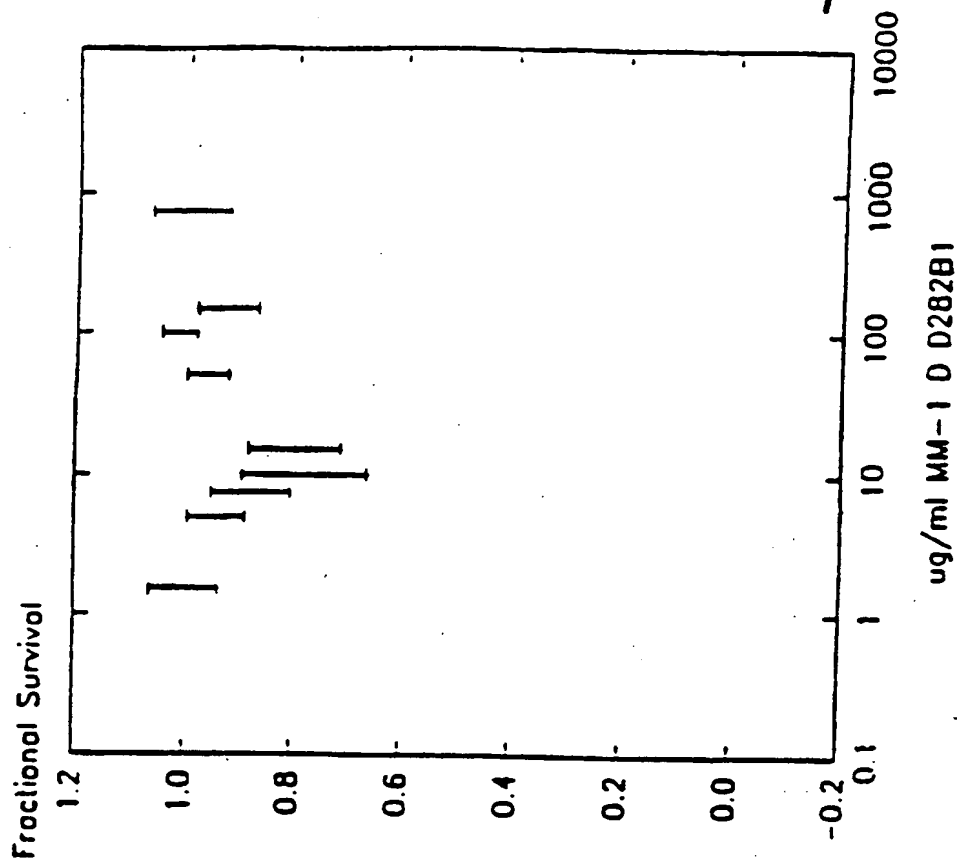


FIG. 18B

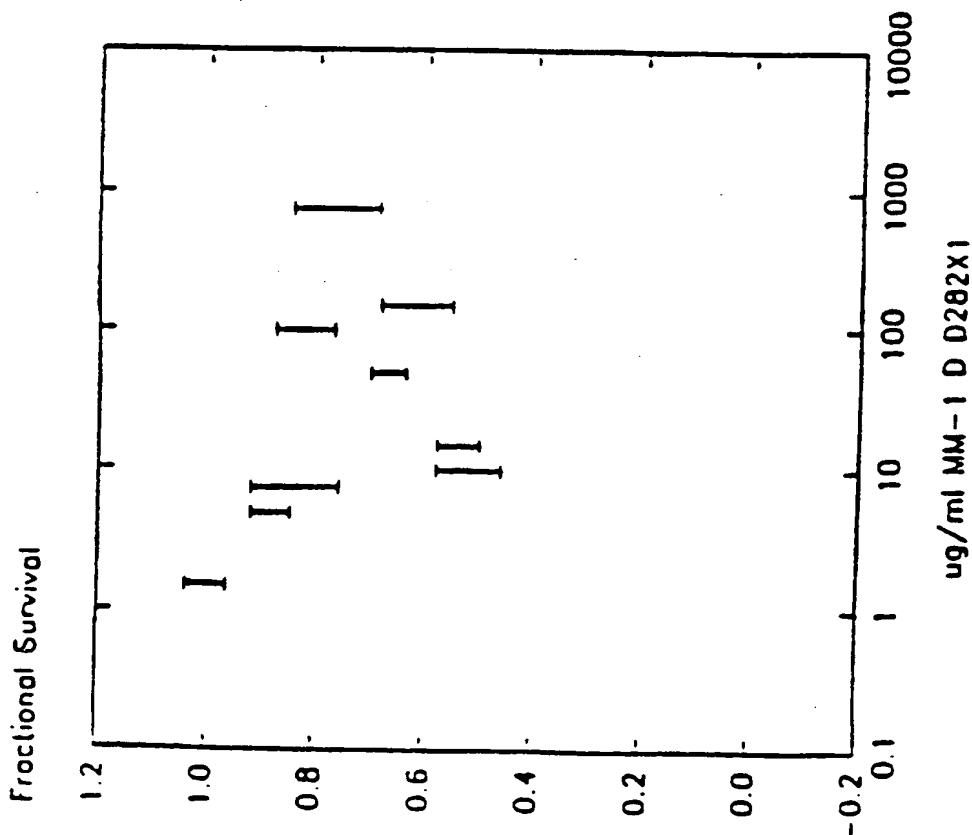
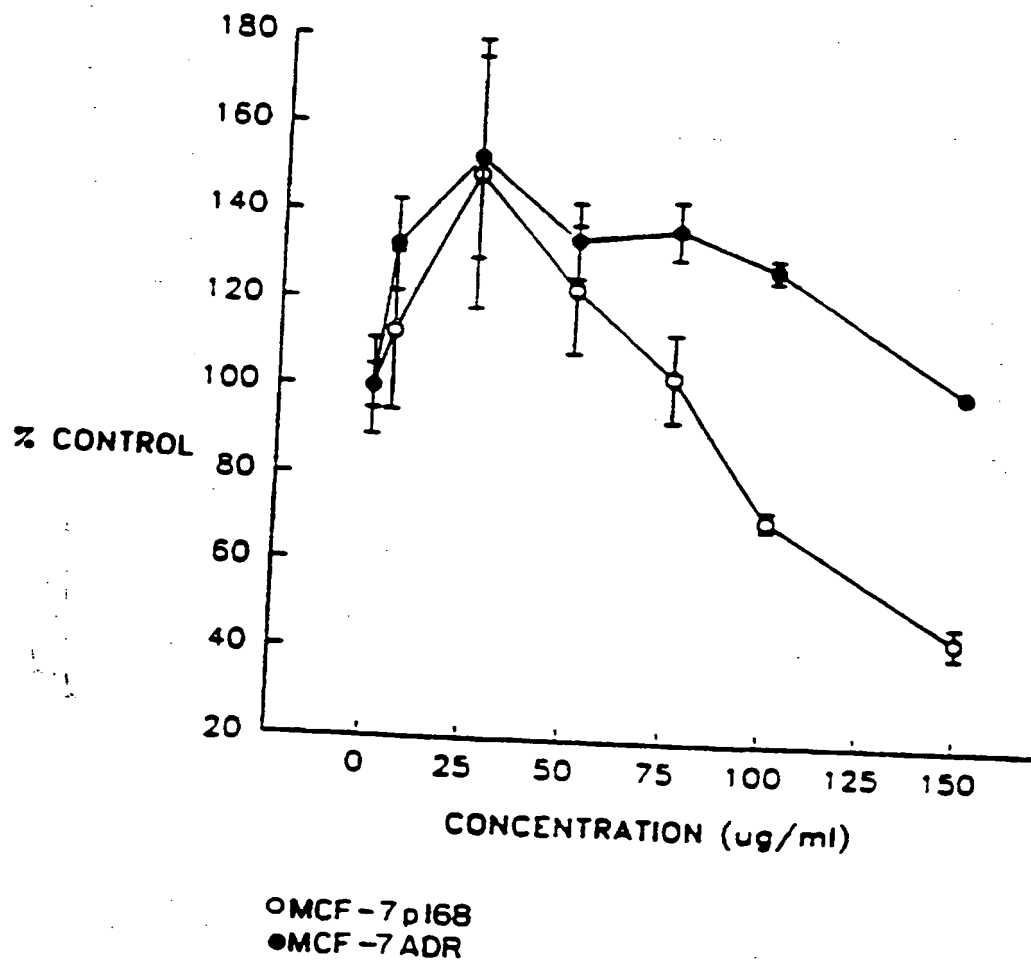


FIG. 18A

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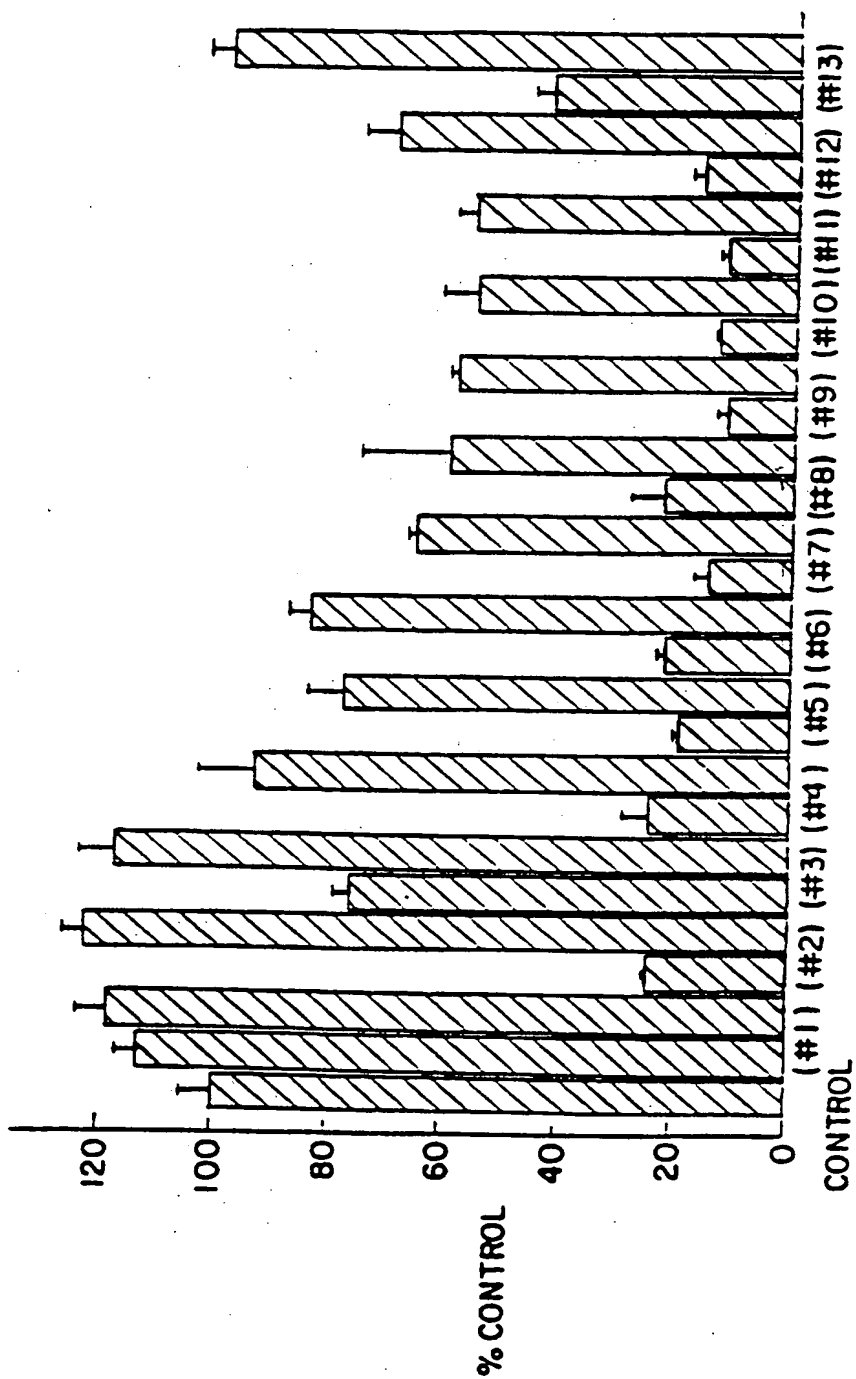
FIG. 19





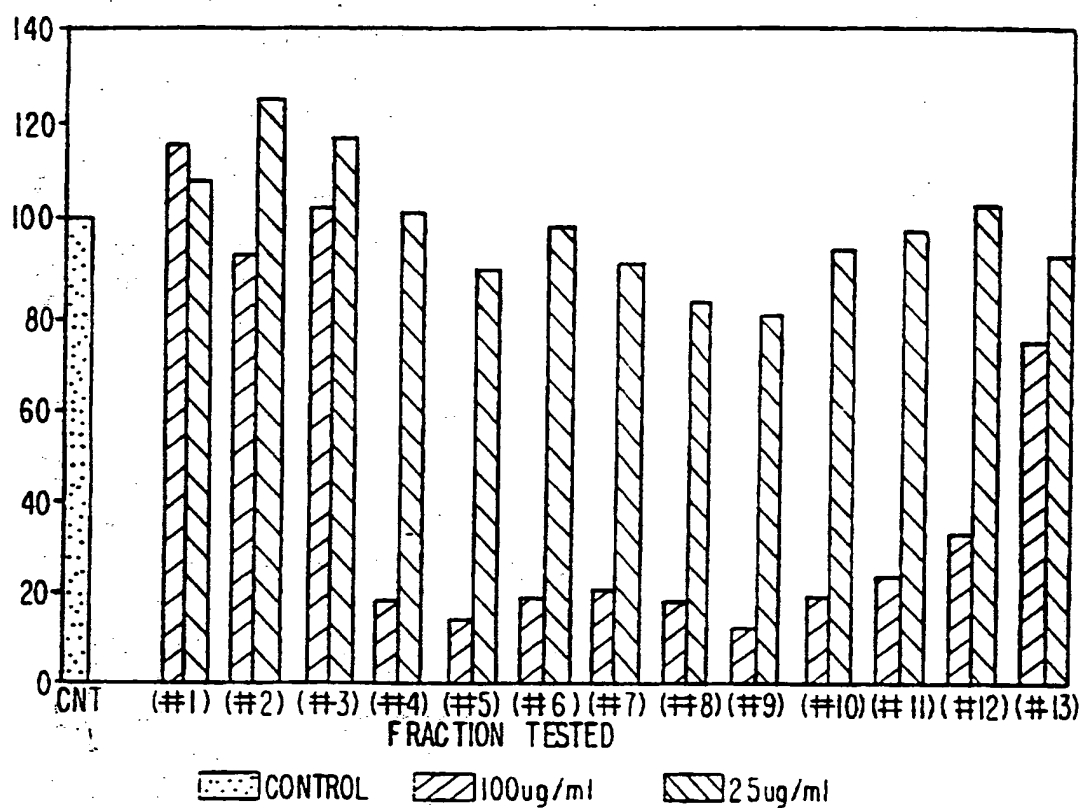
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FIG. 20A



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FIG. 20B

FRACTION NUMBEROLIGOMERIC UNIT

#1	DIMERS
#2	TRIMERS
#3	TETRAMERS
#4	PENTAMERS
#5	HEXAMERS
#6	HEPTAMERS
#7	OCTAMERS
#8	NONAMERS
#9	DECAMERS
#10	UNDECAMERS
#11	DODECAMERS
#12	HIGHER OLIGOMERS
#13	UNKNOWN

FIG. 21A

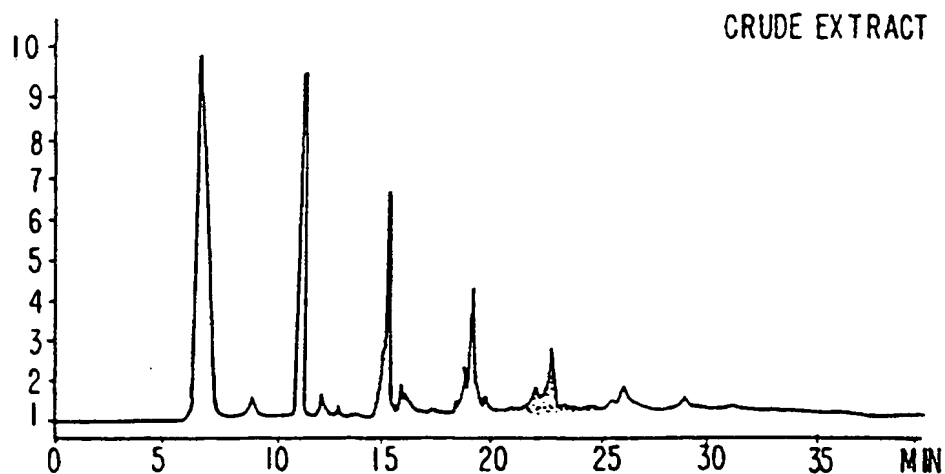


FIG. 21B

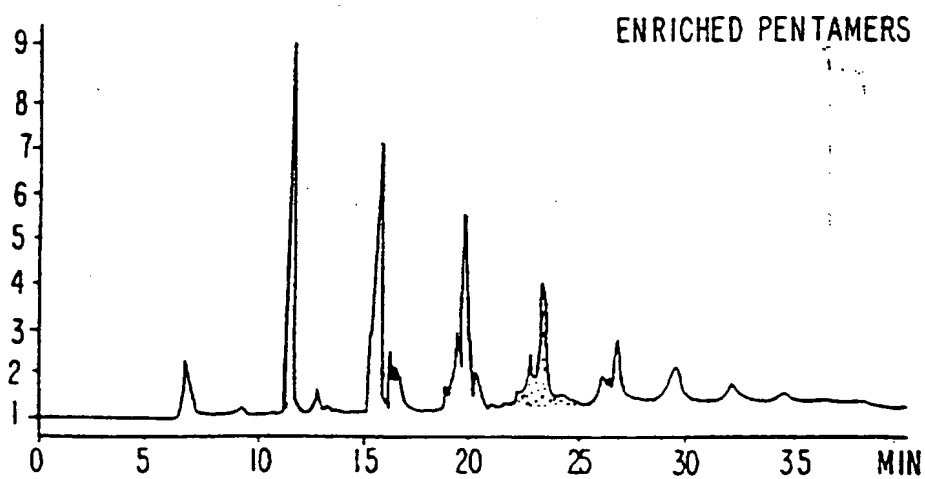
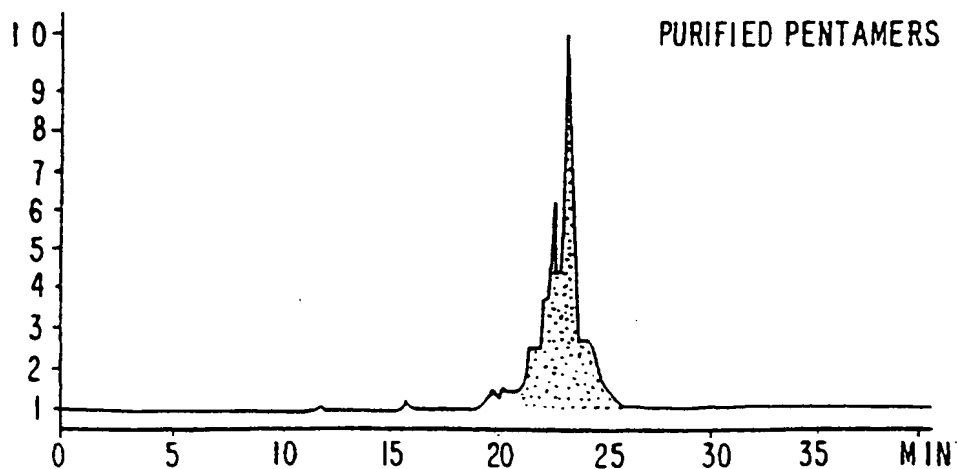
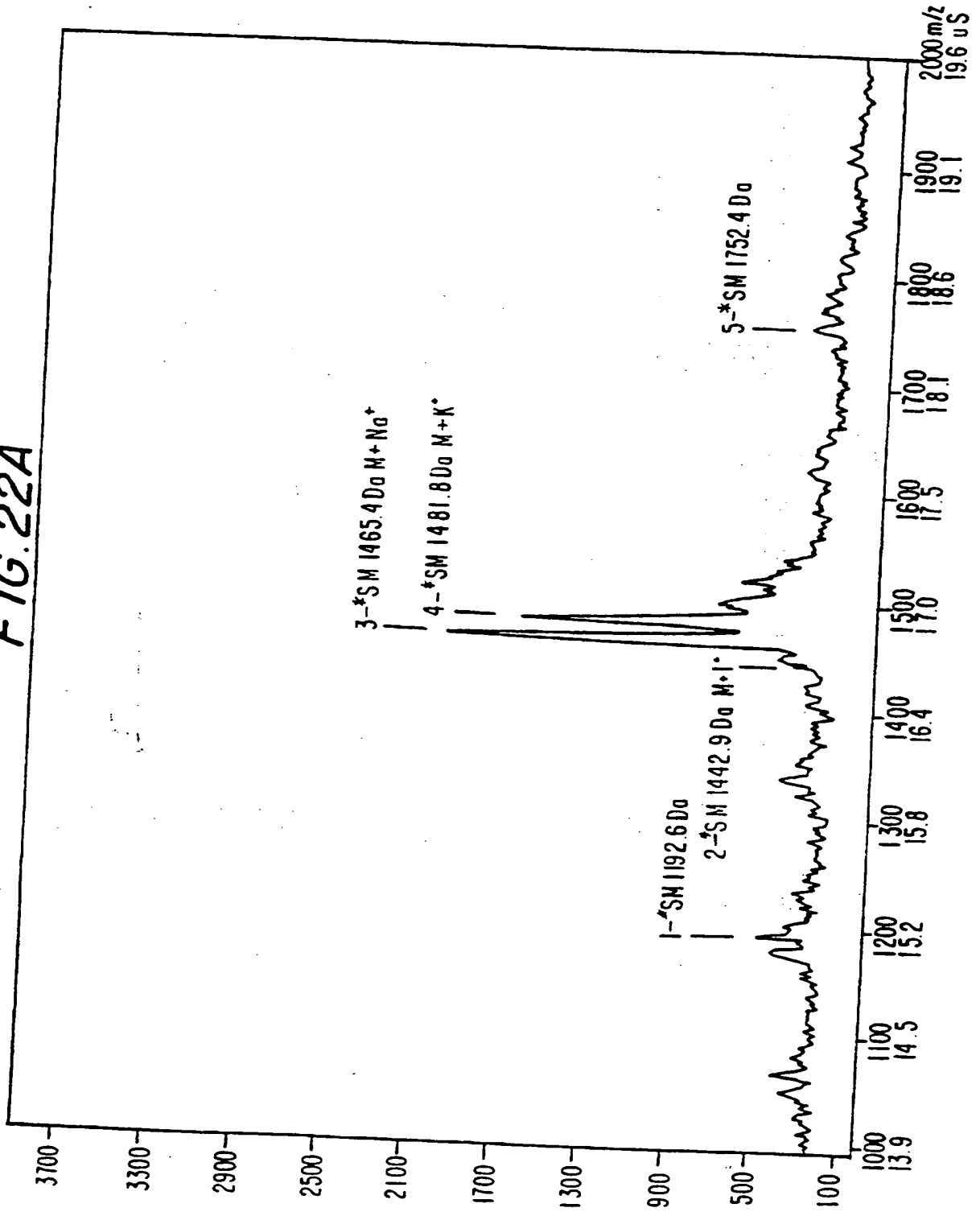


FIG. 21C



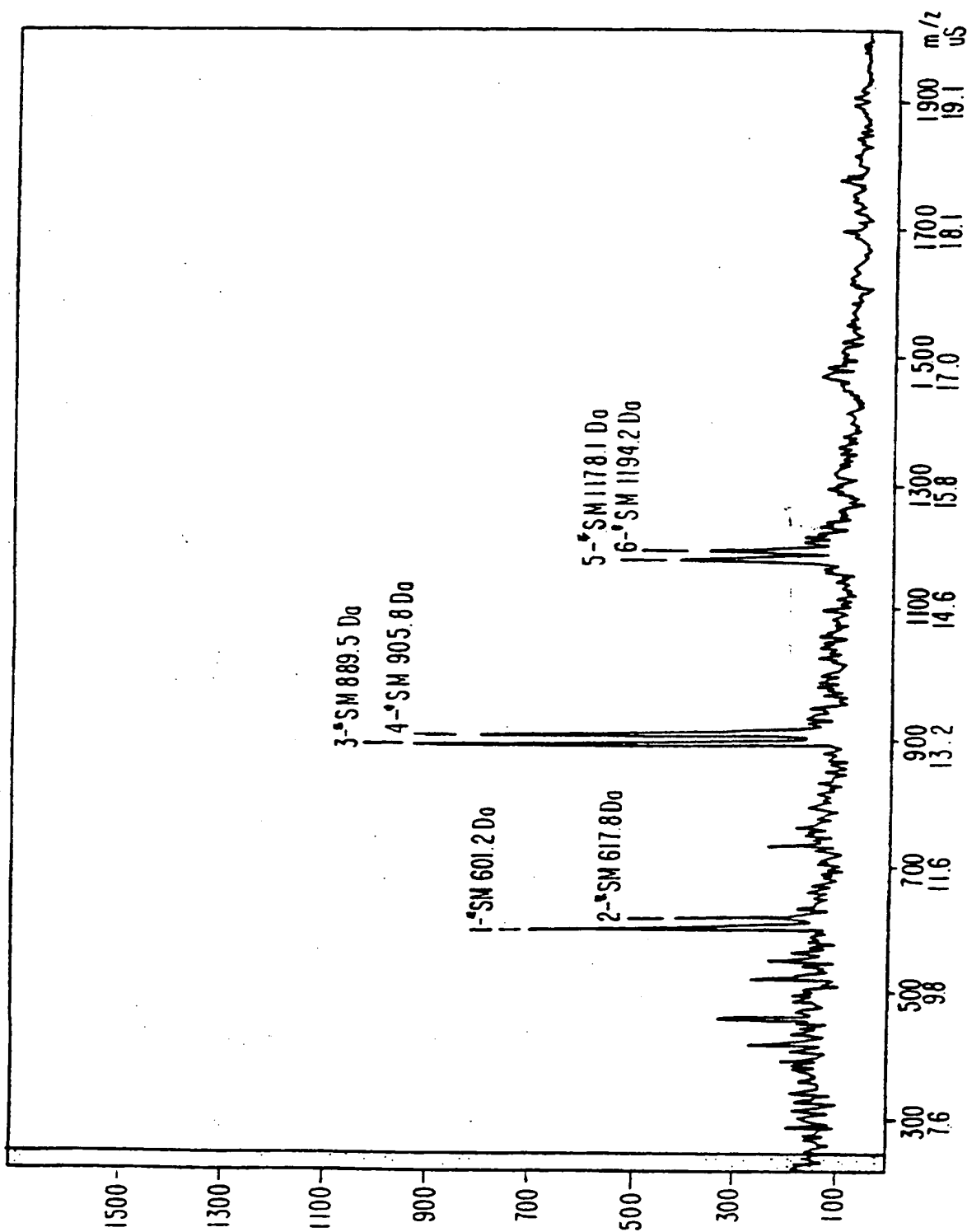
SUBSTITUTE SHEET (RULE 26)

FIG. 22A



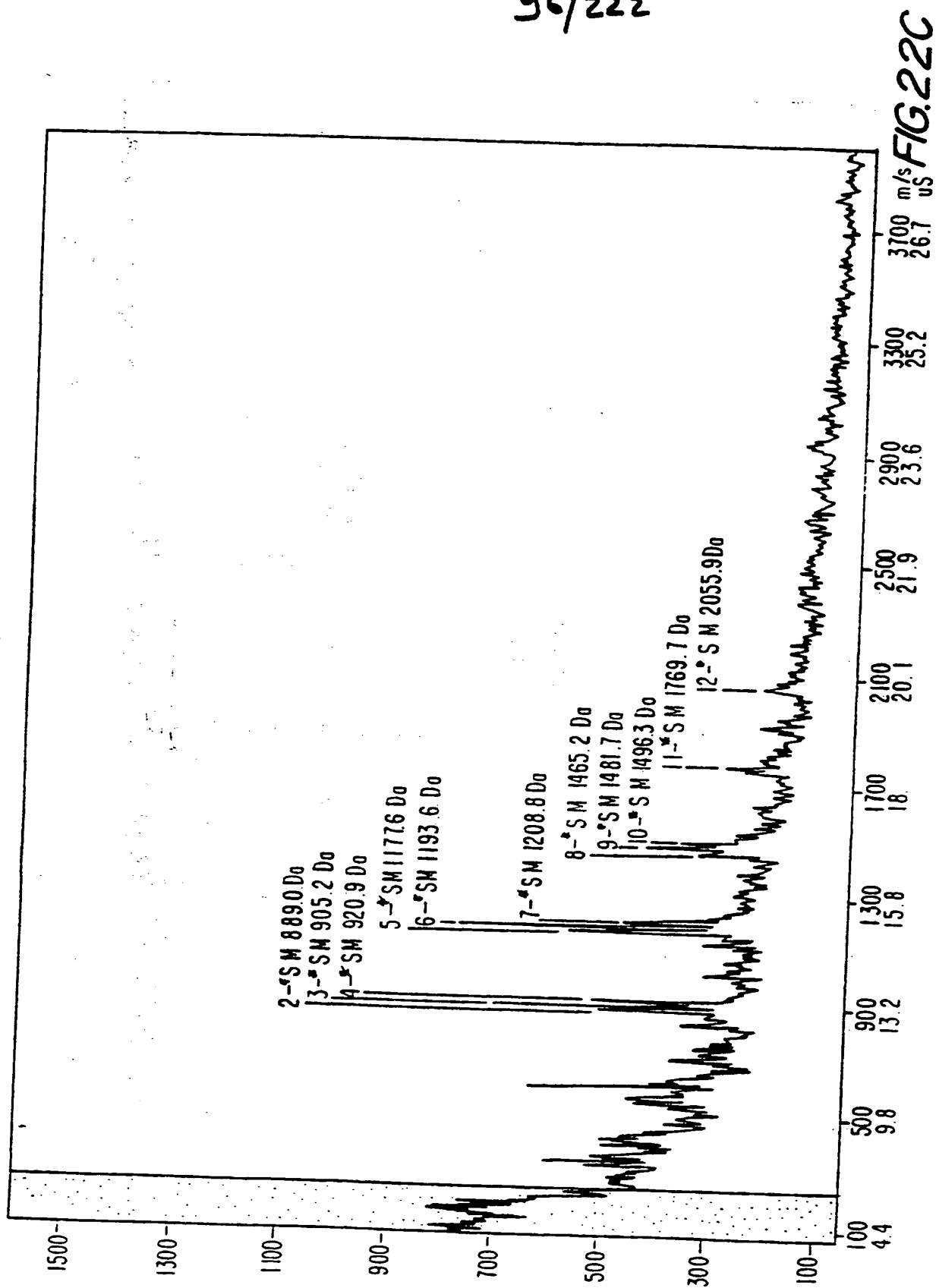
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FIG. 22B



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SUBSTITUTE SHEET (RULE 26)

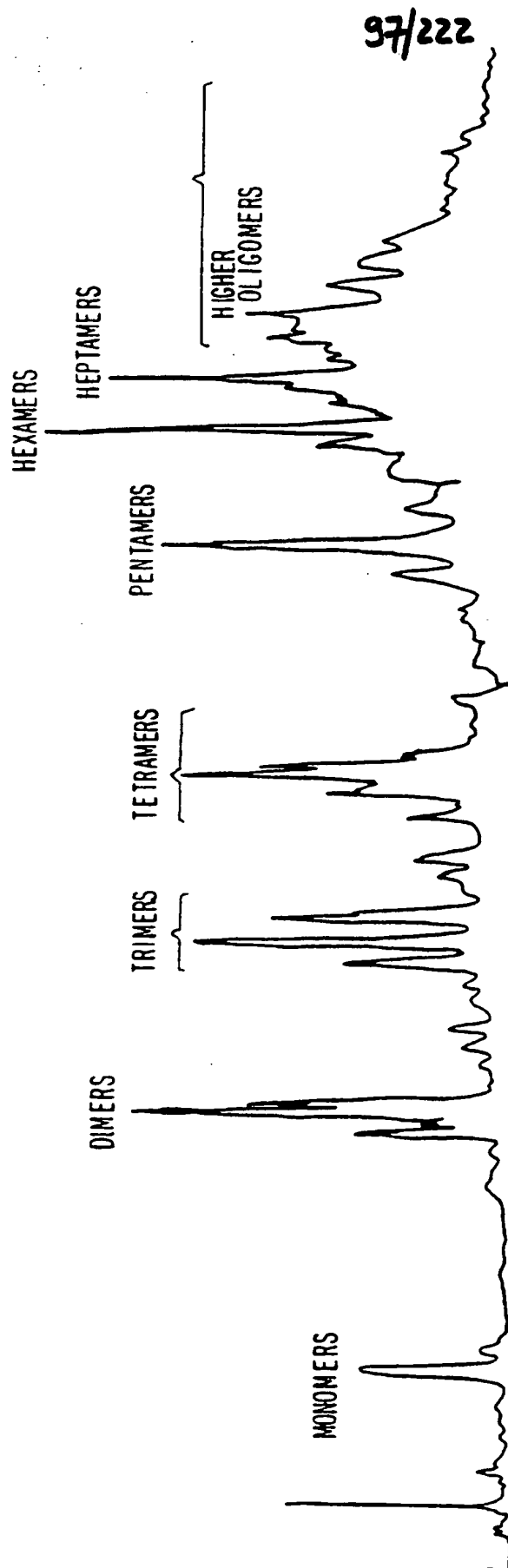
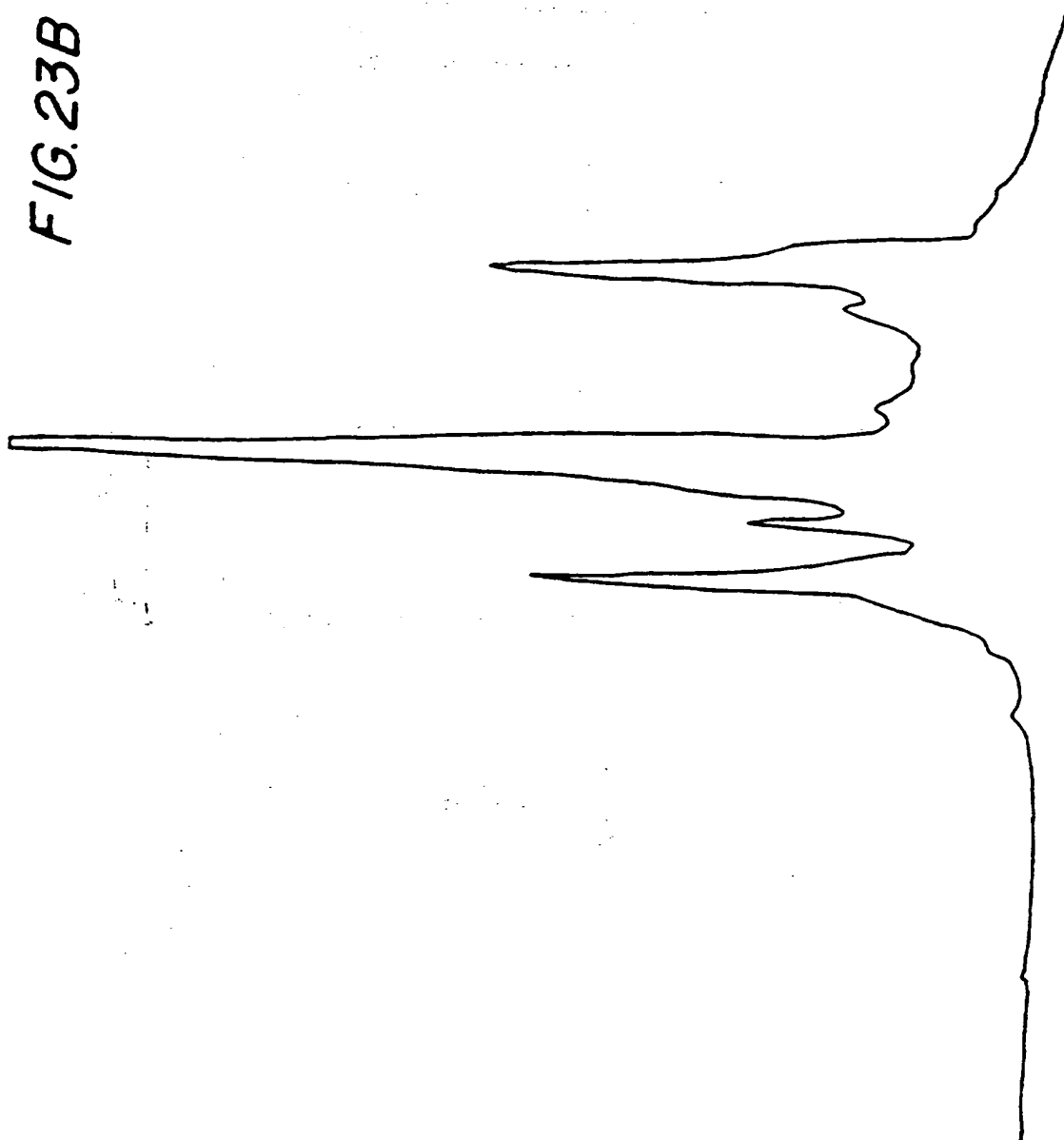


FIG. 23A

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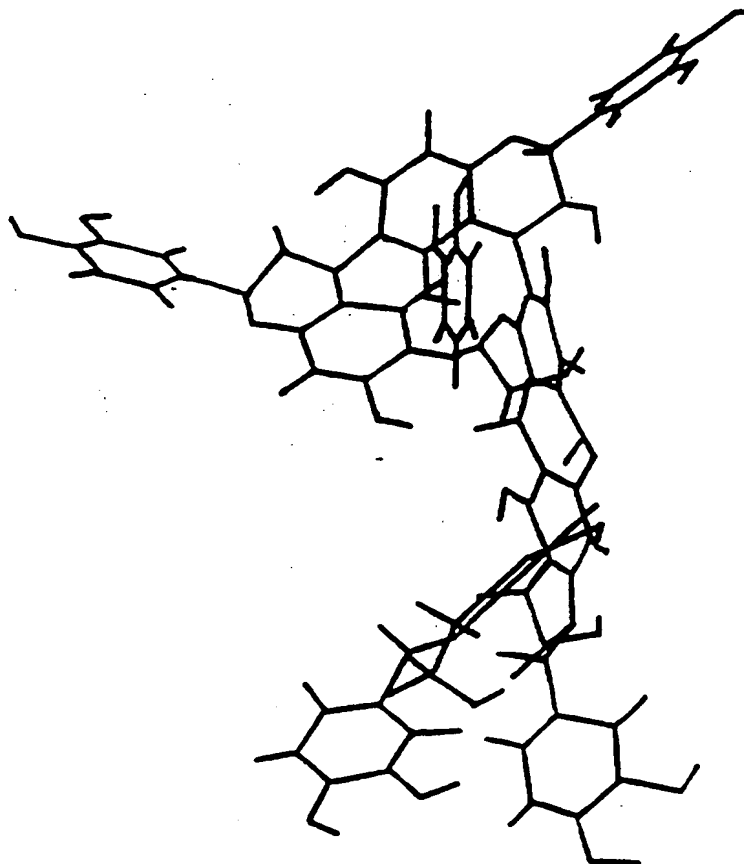
FIG. 23B





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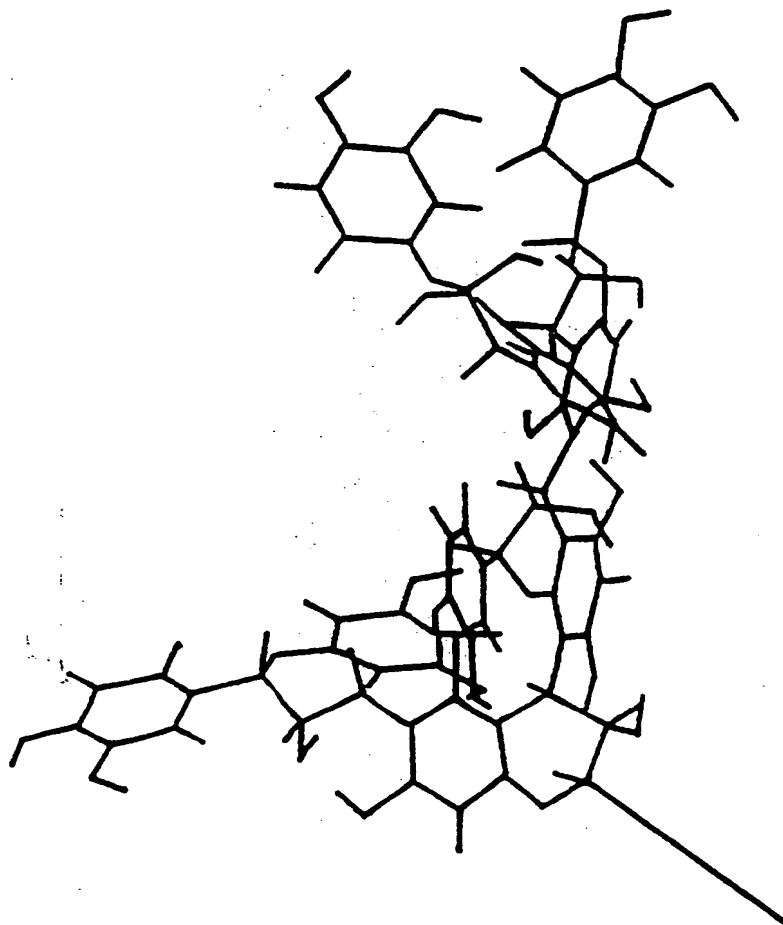
FIG. 24A



SUBSTITUTE SHEET (RULE 26)

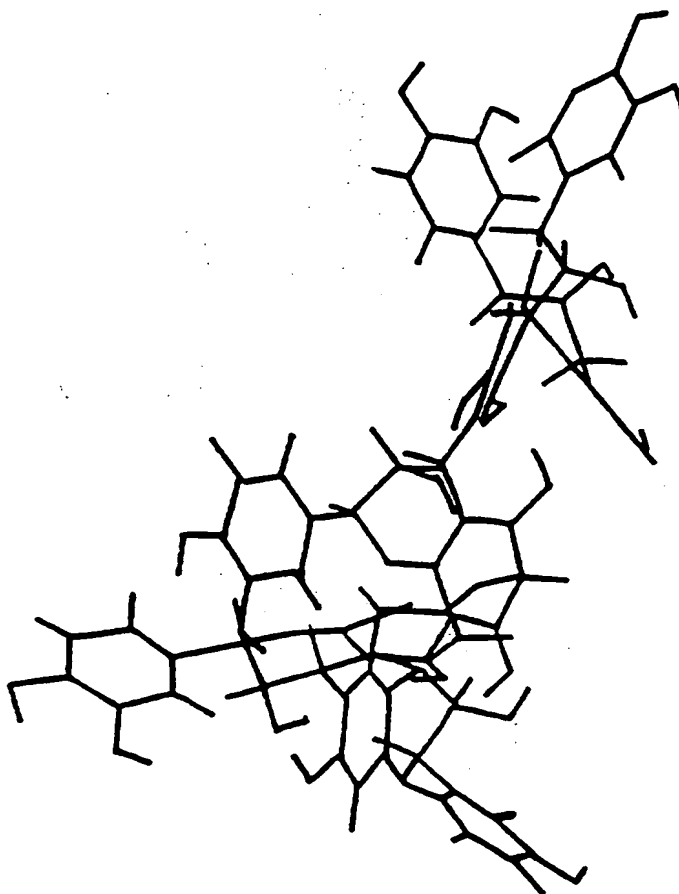
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FIG. 24B



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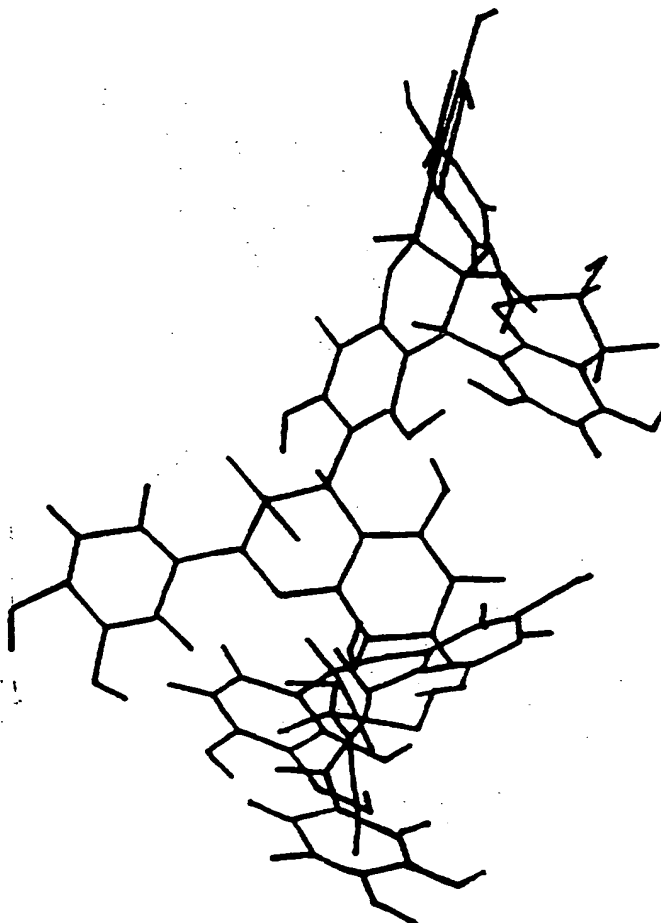
FIG. 24C



SUBSTITUTE SHEET (RULE 26)

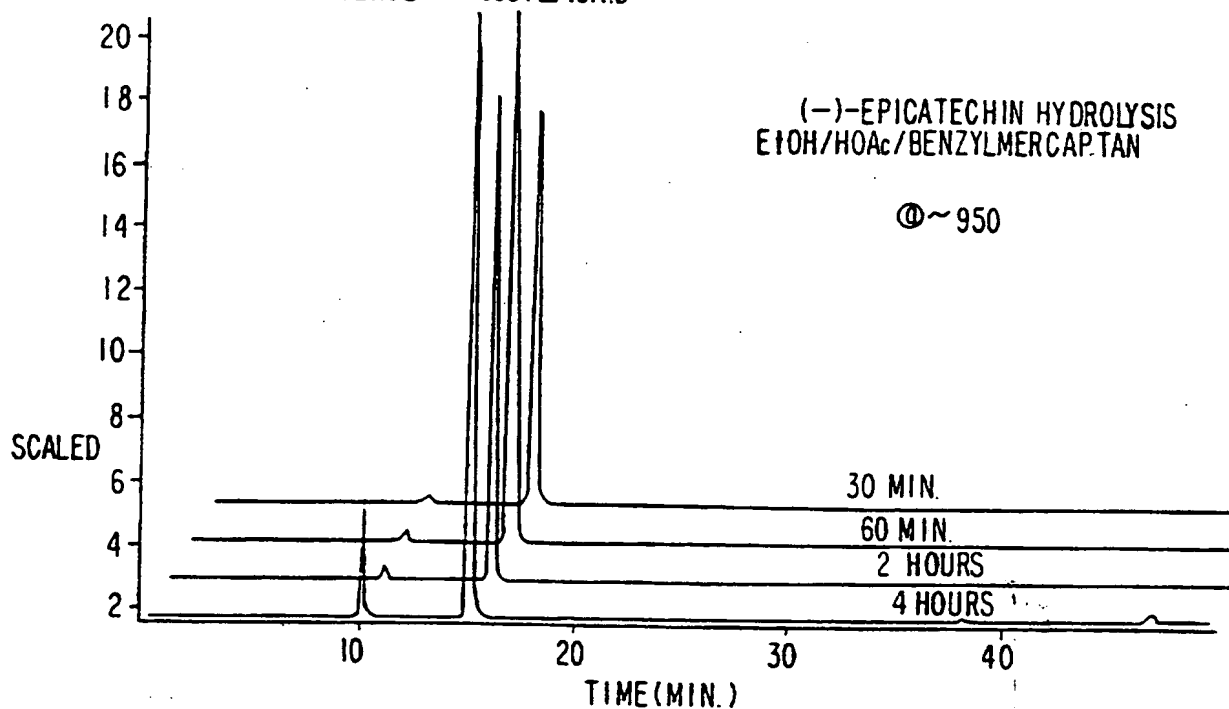
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FIG. 24D



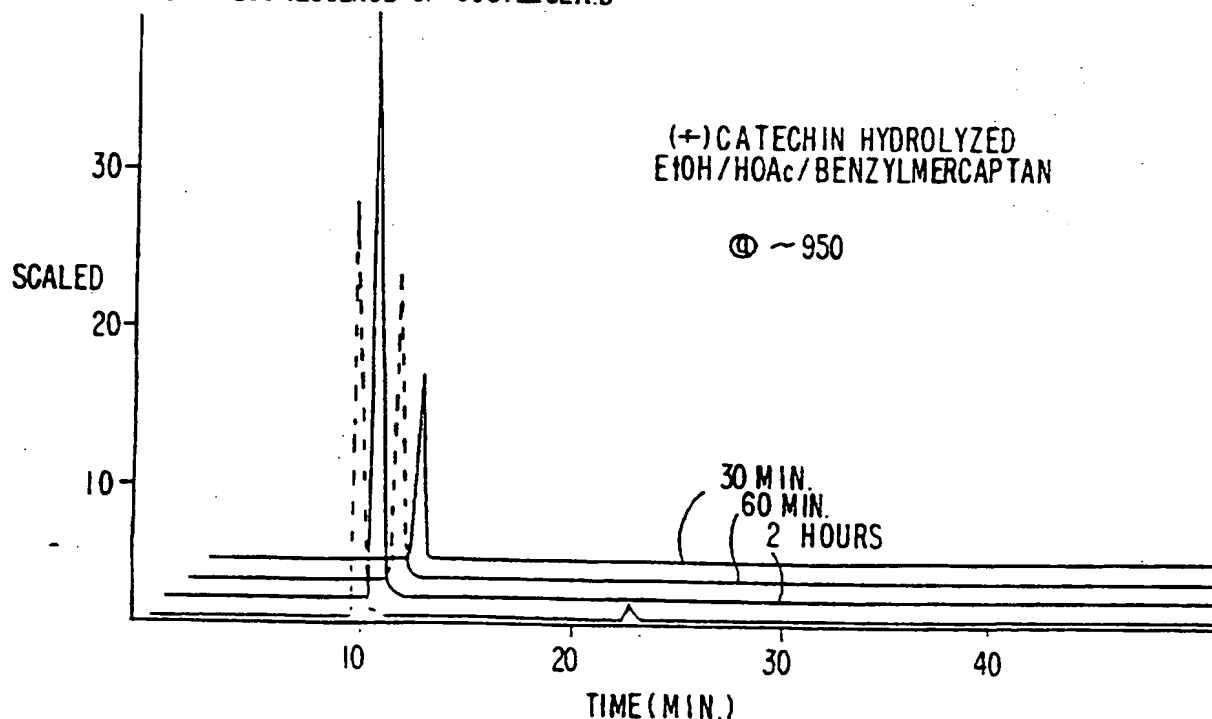
LC X FLUORESCENCE OF 6057\_45A.D  
LC X FLUORESCENCE OF 6057\_46A.D  
LC X FLUORESCENCE OF 6057\_47A.D  
LC X FLUORESCENCE OF 6057\_48A.D

FIG. 25A



LC X FLUORESCENCE OF 6057\_49A.D  
LC X FLUORESCENCE OF 6057\_50A.D  
LC X FLUORESCENCE OF 6057\_51A.D  
LC X FLUORESCENCE OF 6057\_52A.D

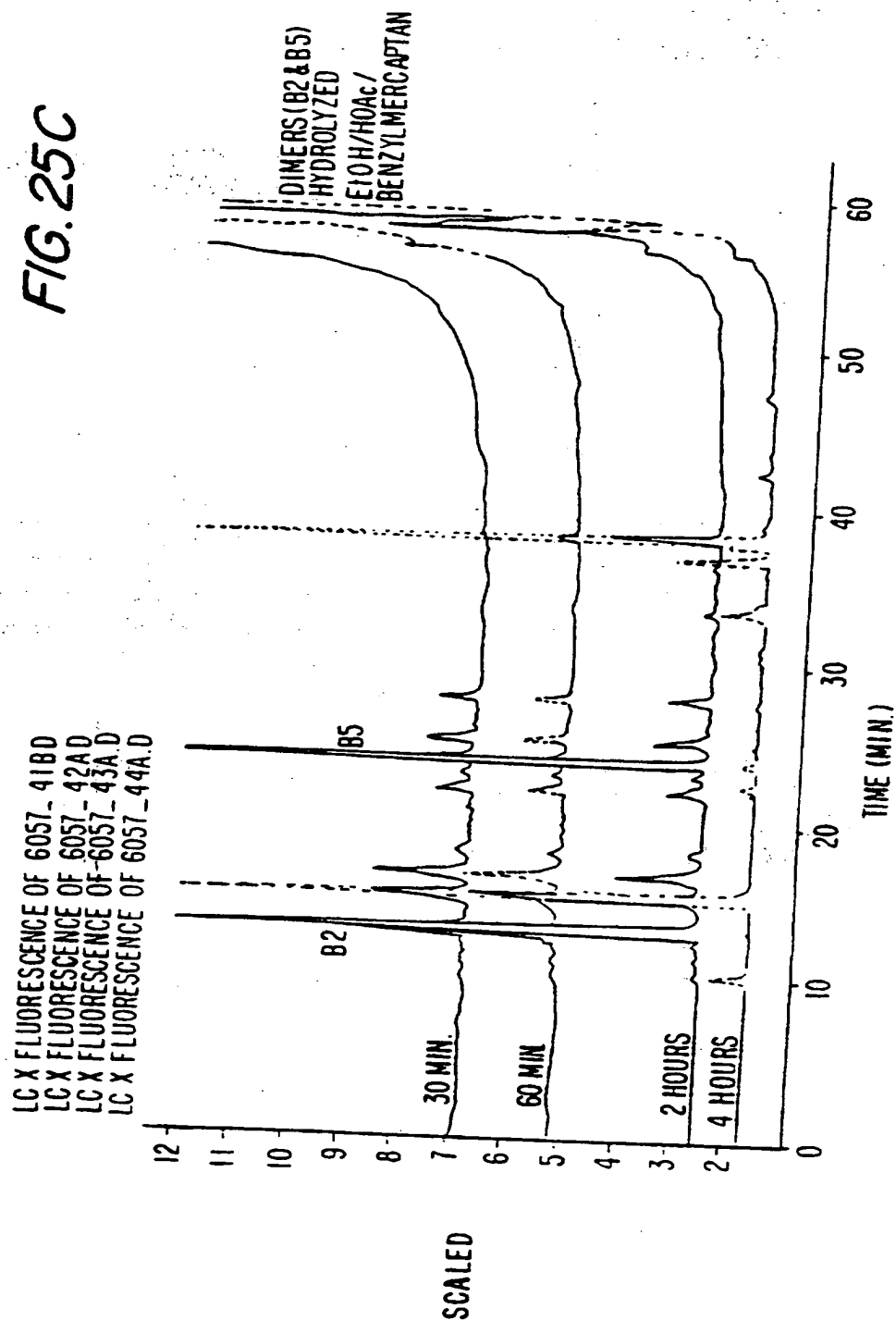
FIG. 25B



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FIG. 25C



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FIG. 26A

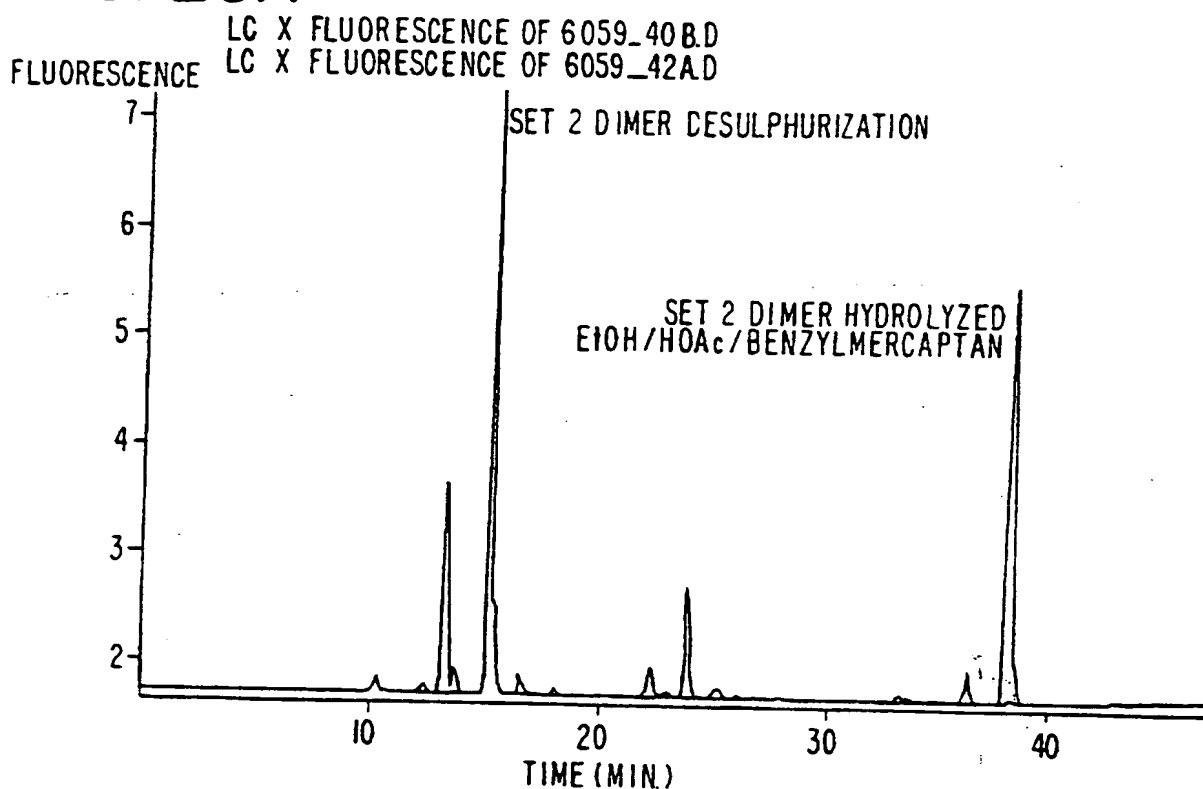
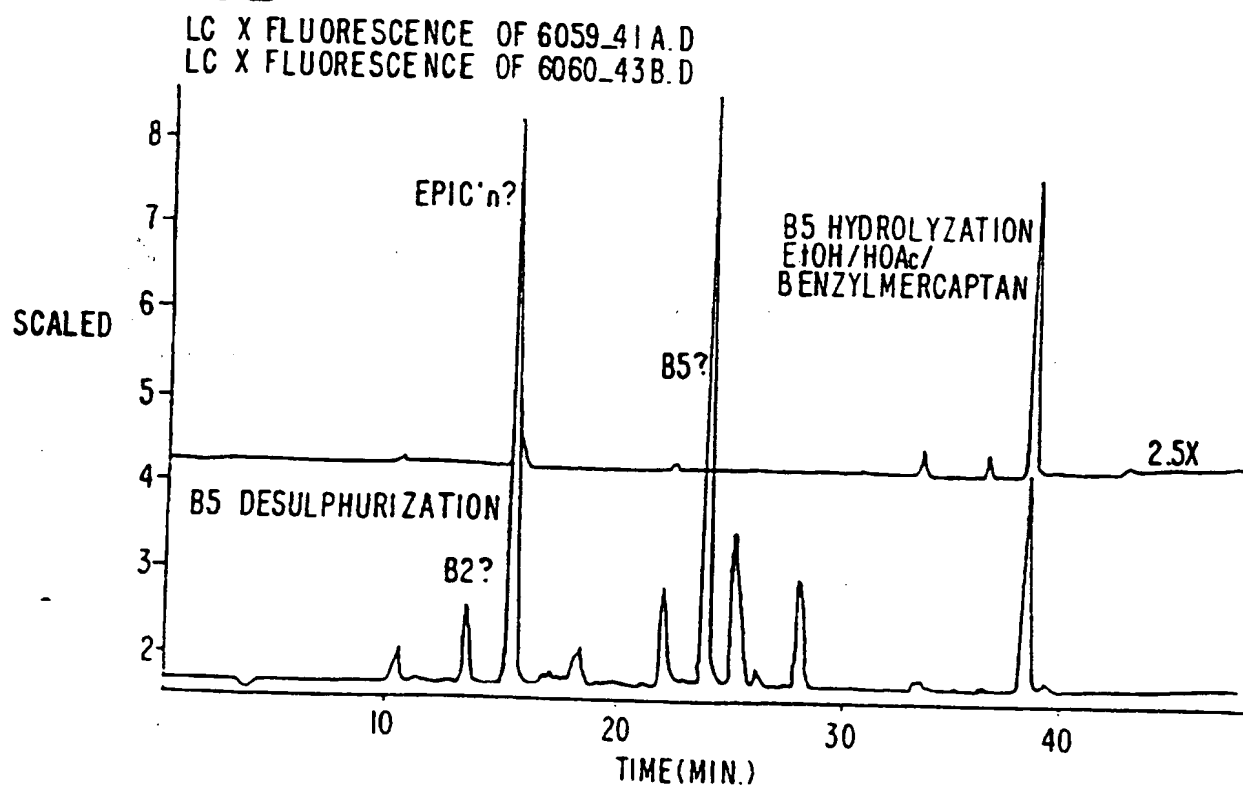


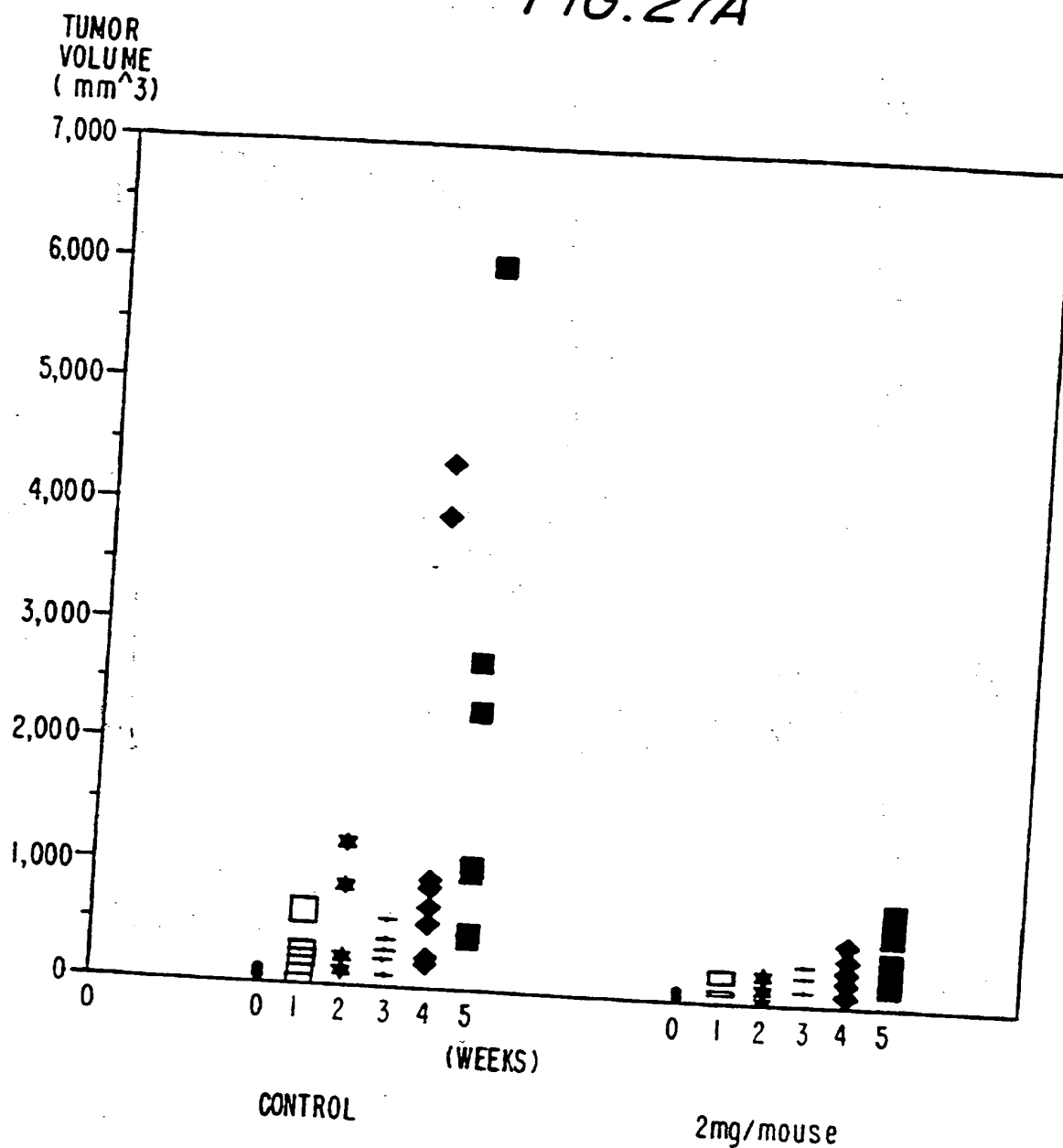
FIG. 26B



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FIG. 27A



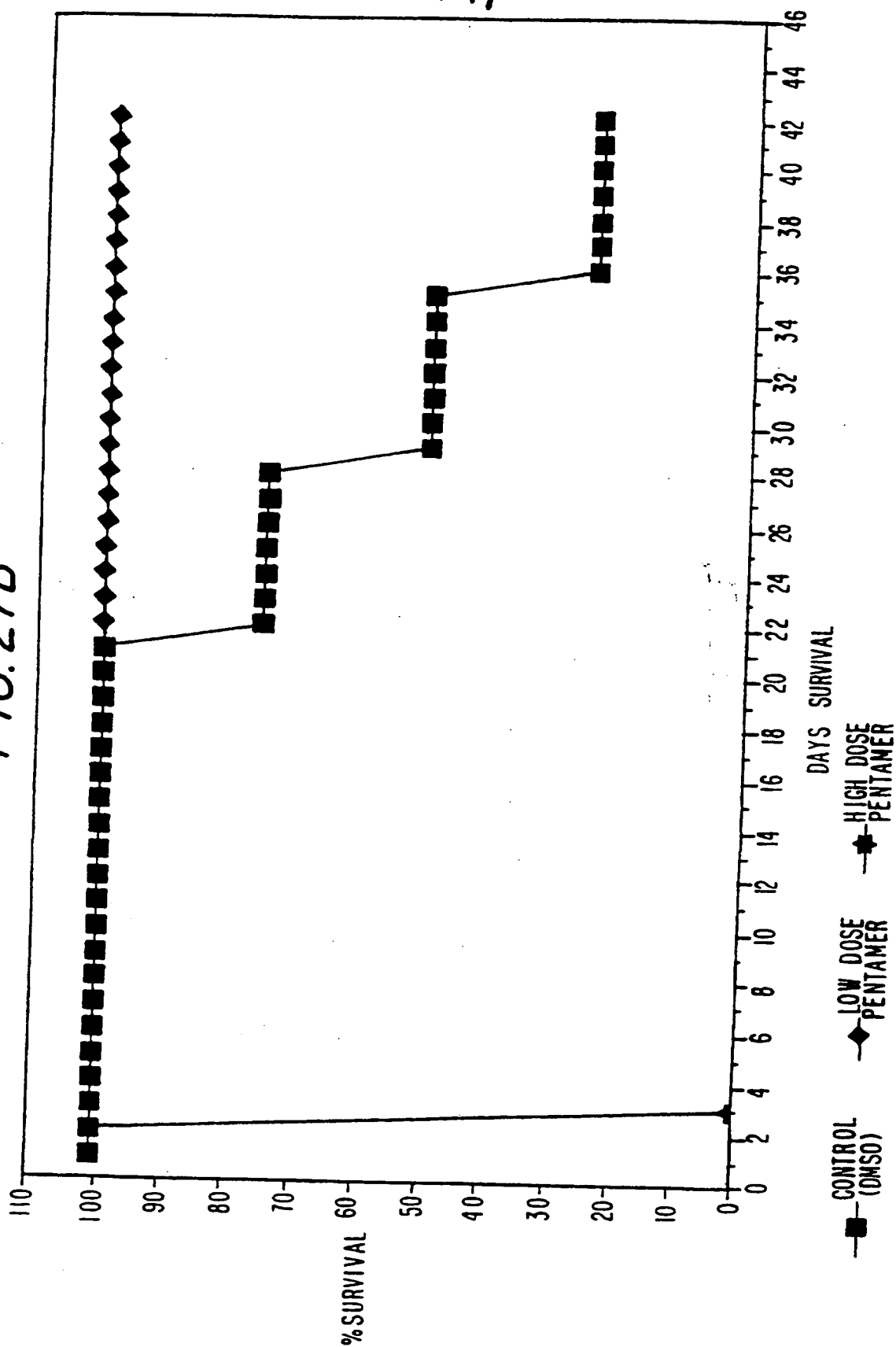
T VALUE = 2.68

P VALUE = 0.02



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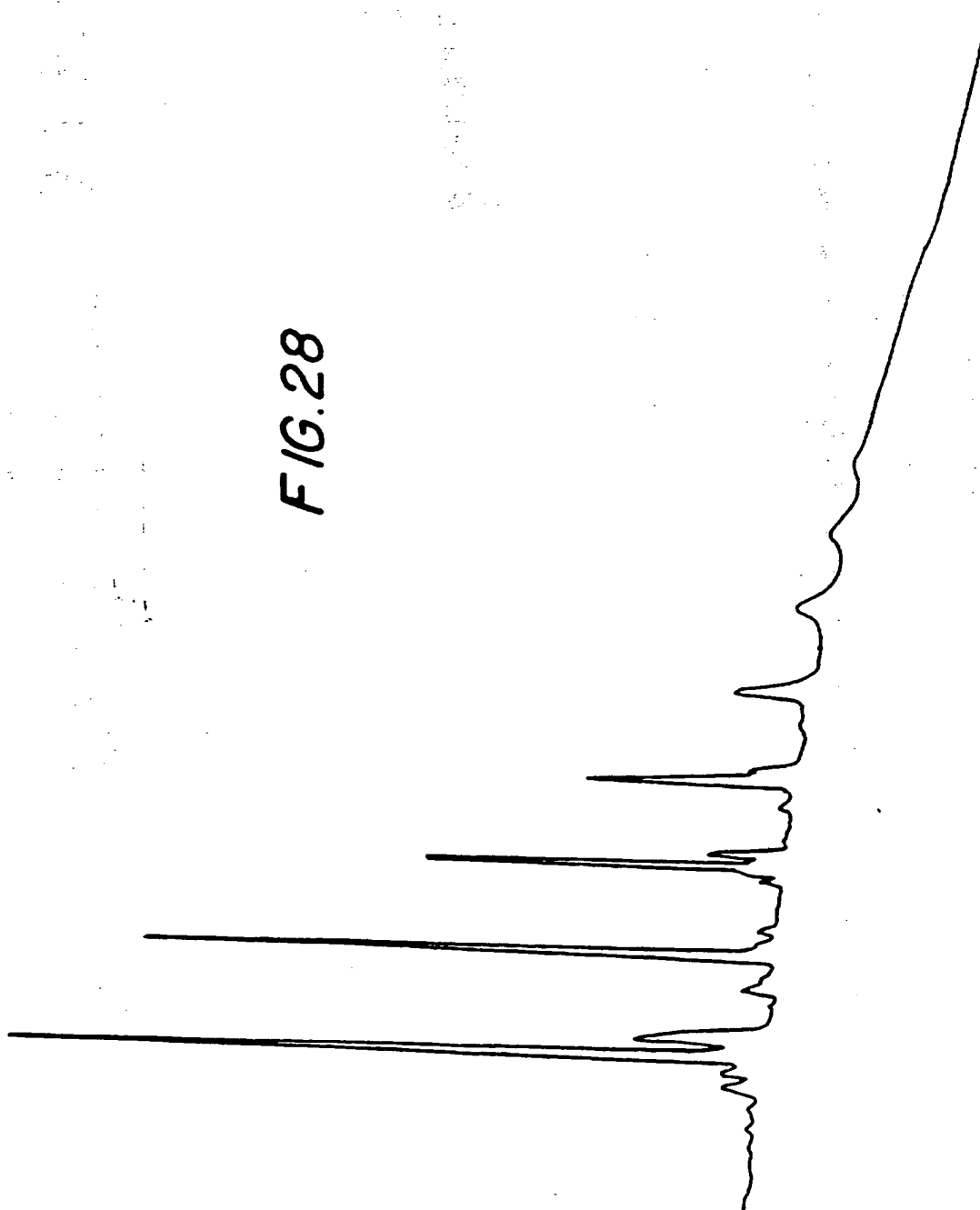
FIG. 27B



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FIG. 28



SUBSTITUTE SHEET (RULE 26)

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FIG. 29A

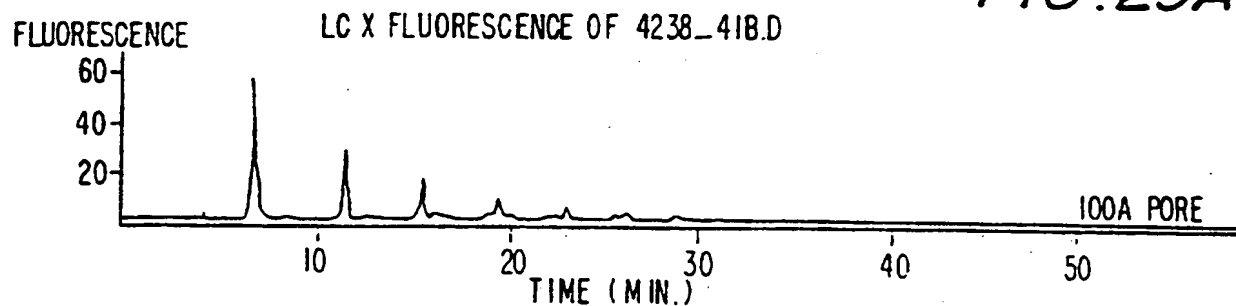


FIG. 29B

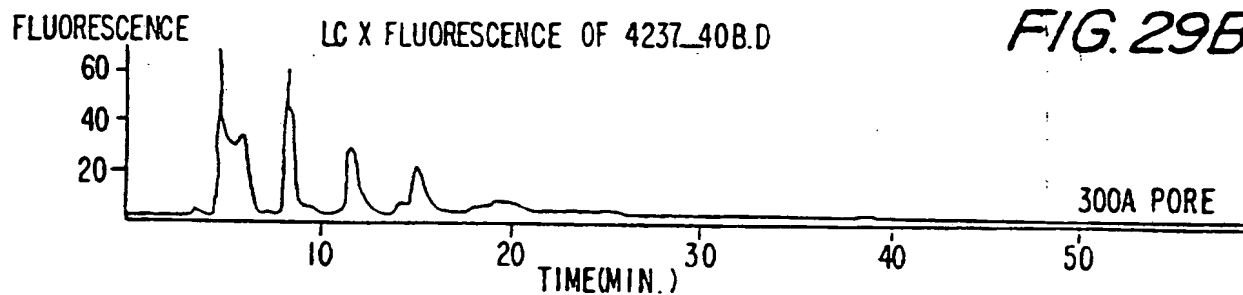
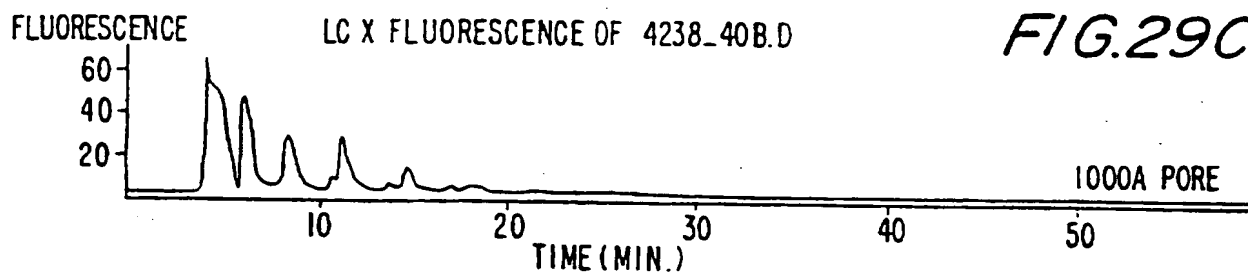


FIG. 29C



SUBSTITUTE SHEET (RULE 26)

FIG. 30A

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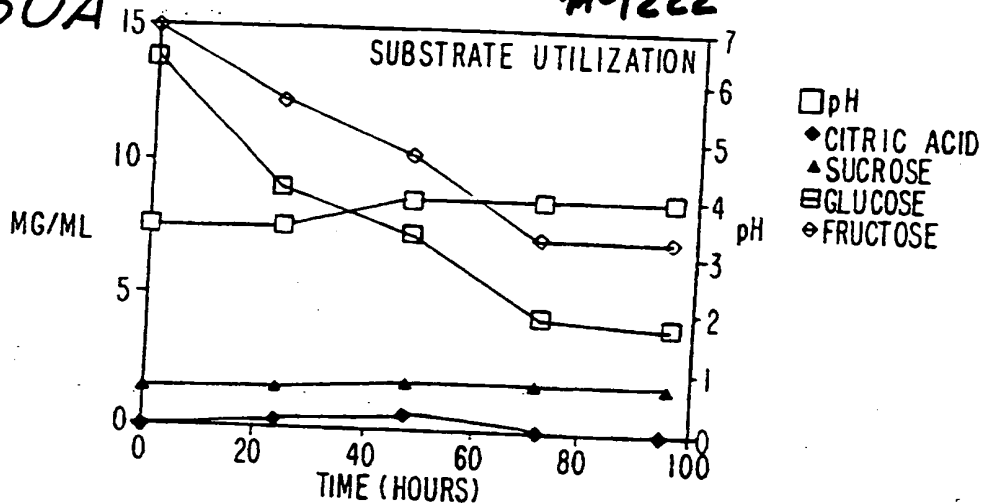


FIG. 30B

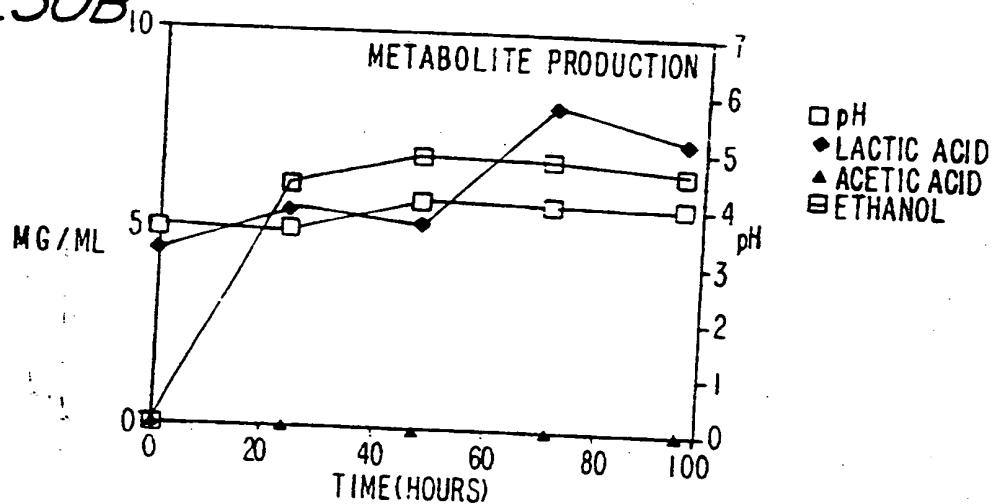
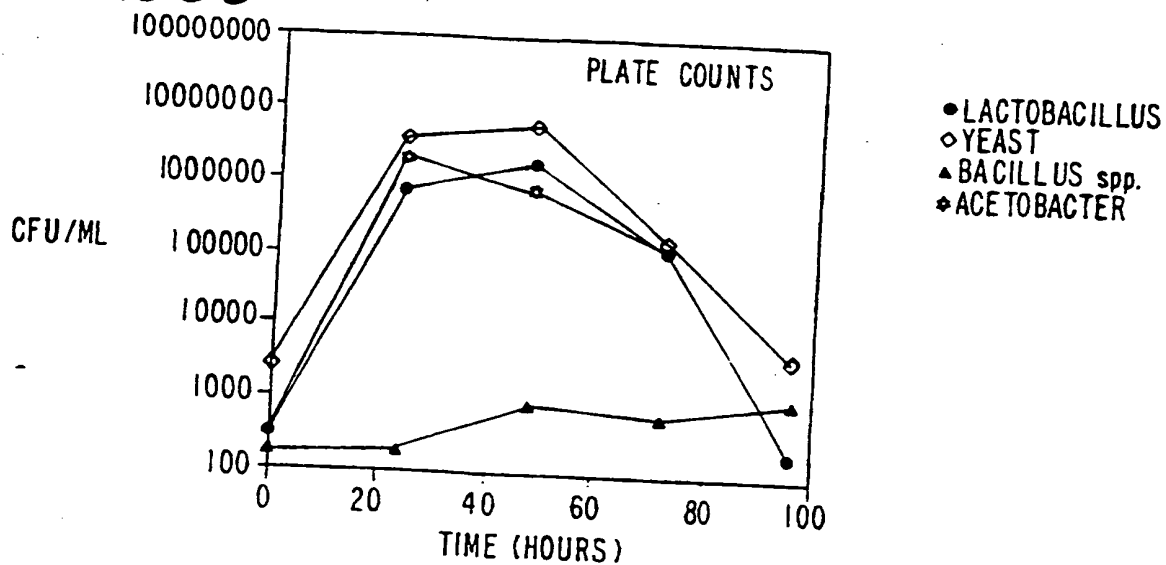
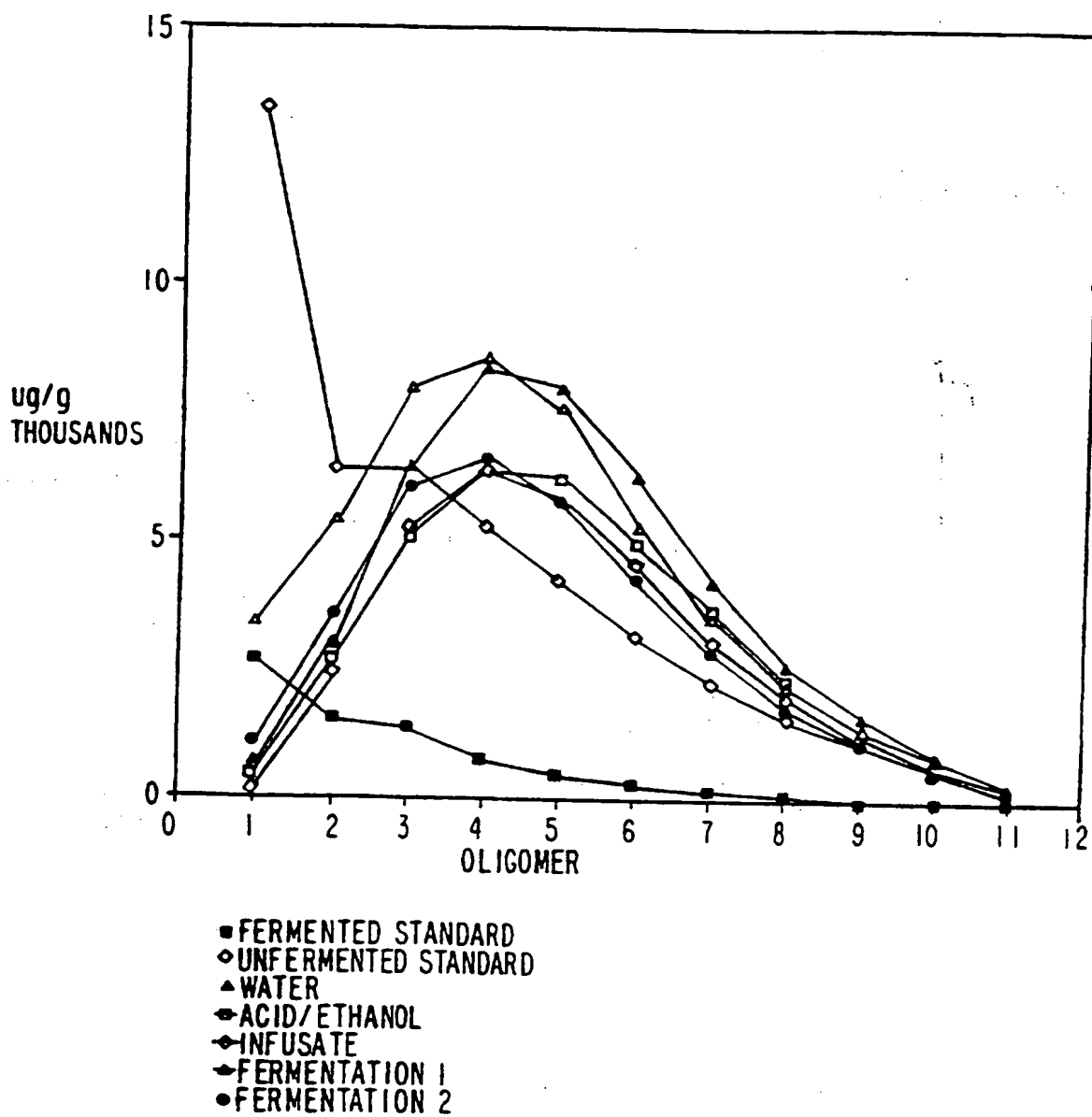


FIG. 30C



SUBSTITUTE SHEET (RULE 26)

FIG. 30D

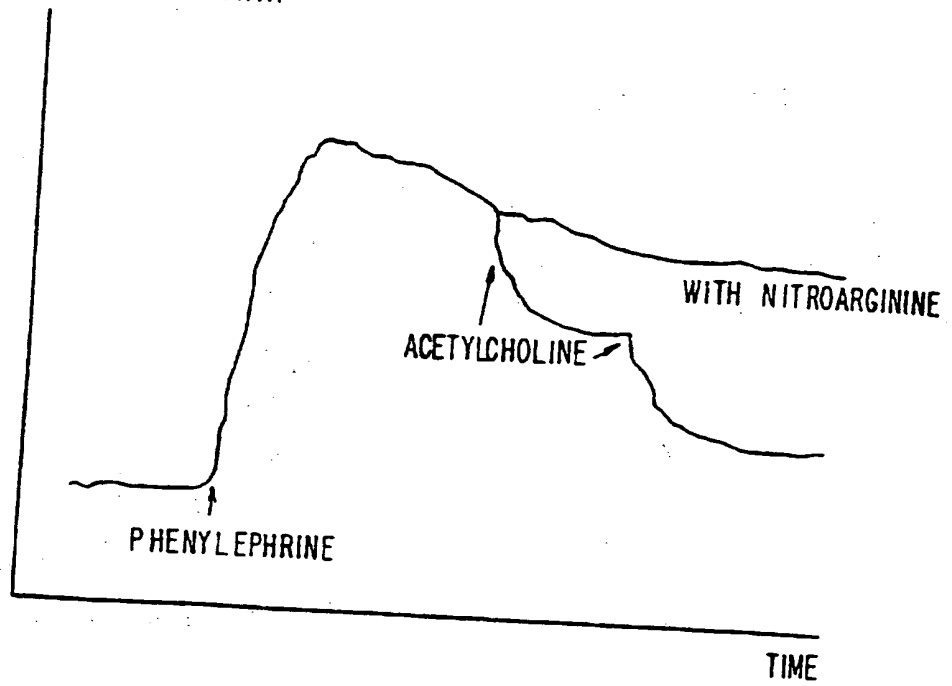


SUBSTITUTE SHEET (RULE 26)

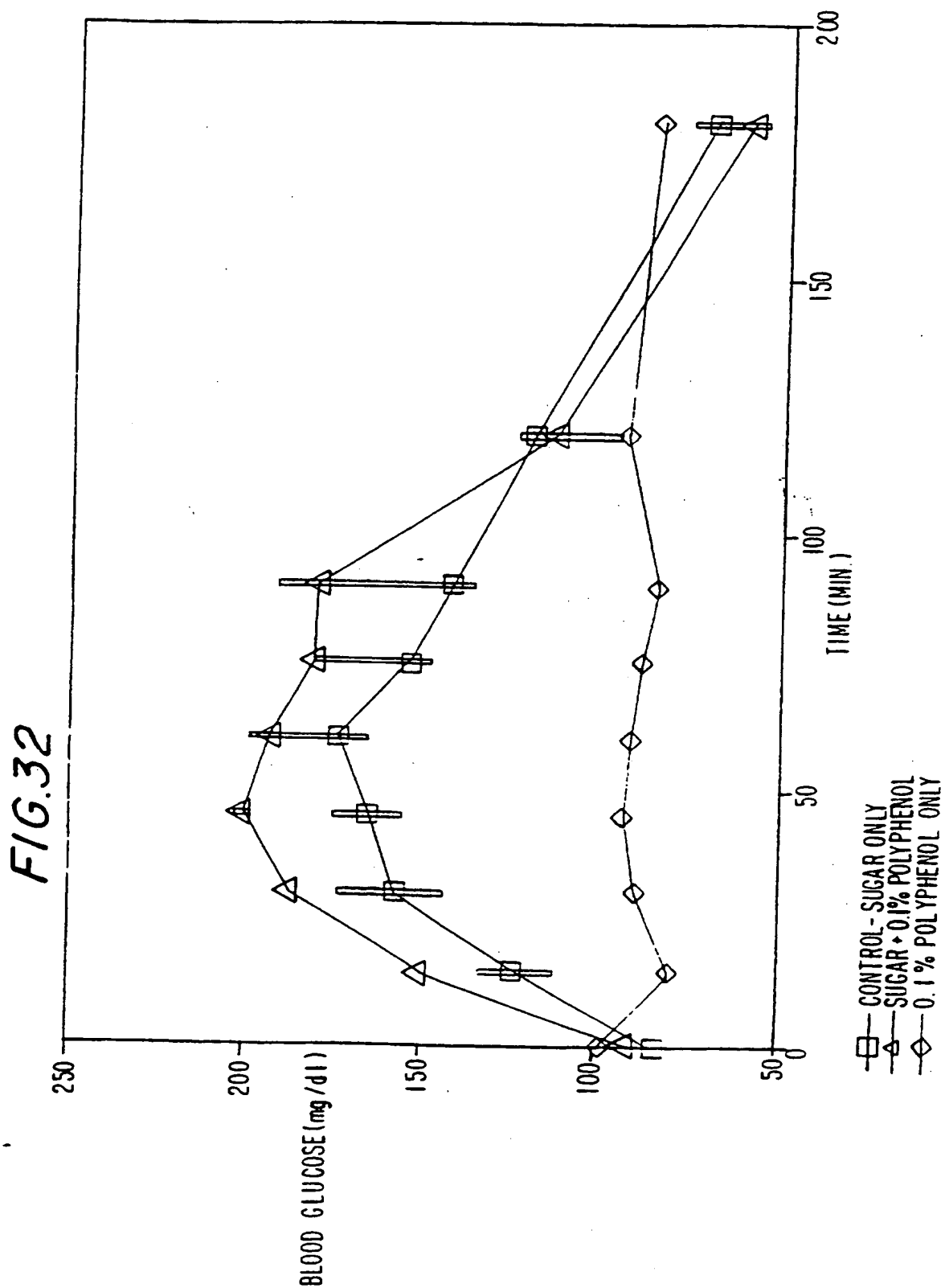
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FIG. 31

CONTRACTION OF ISOLATED AORTA



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SUBSTITUTE SHEET (RULE 26)

FIG. 33A

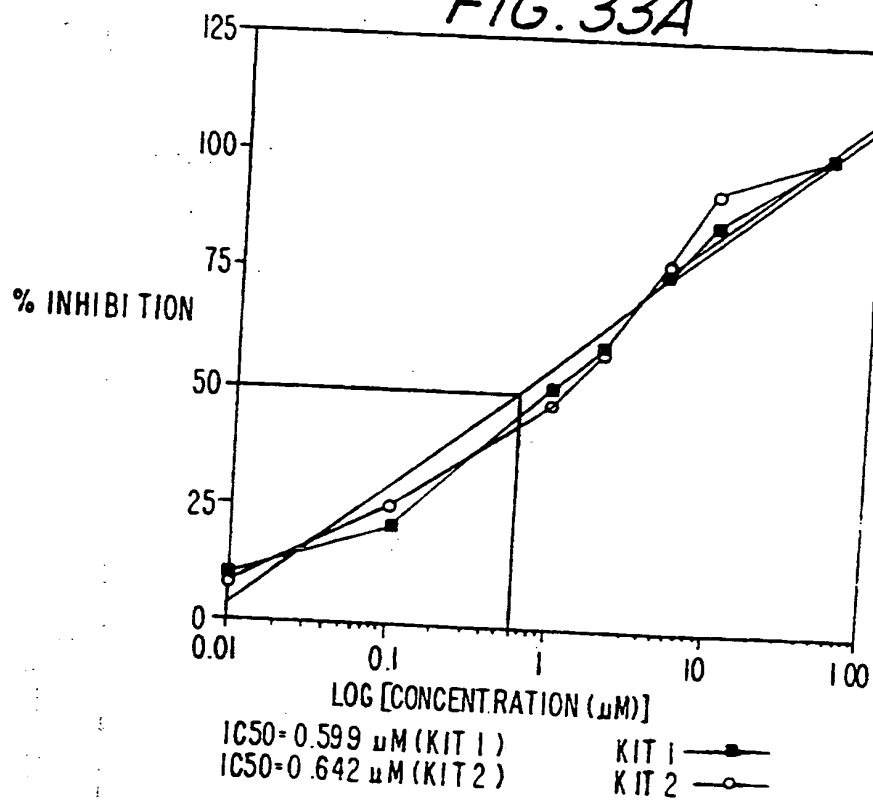
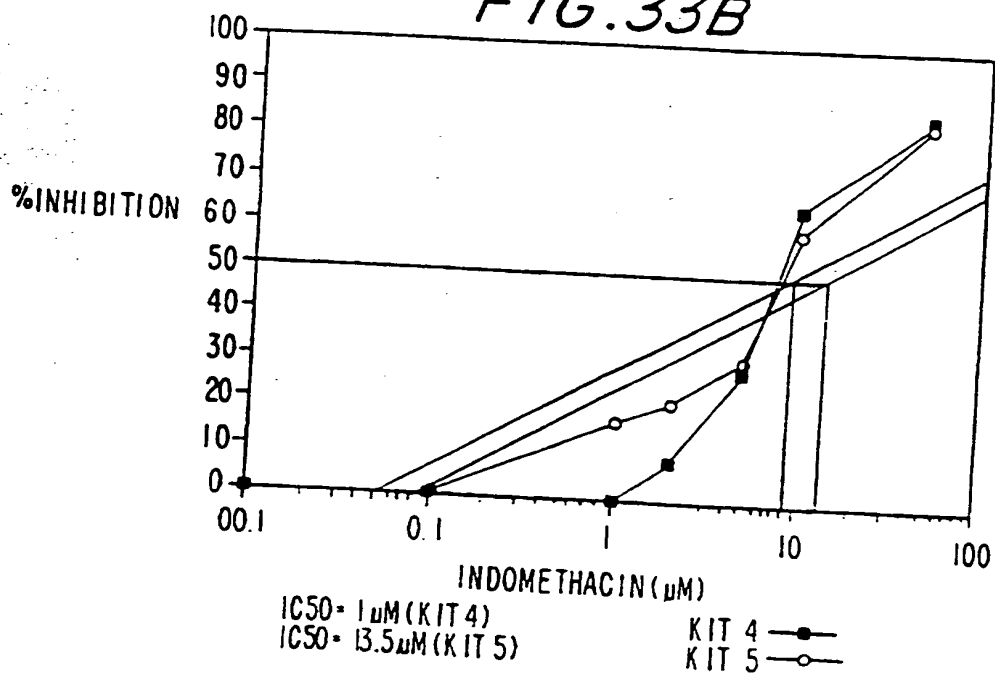


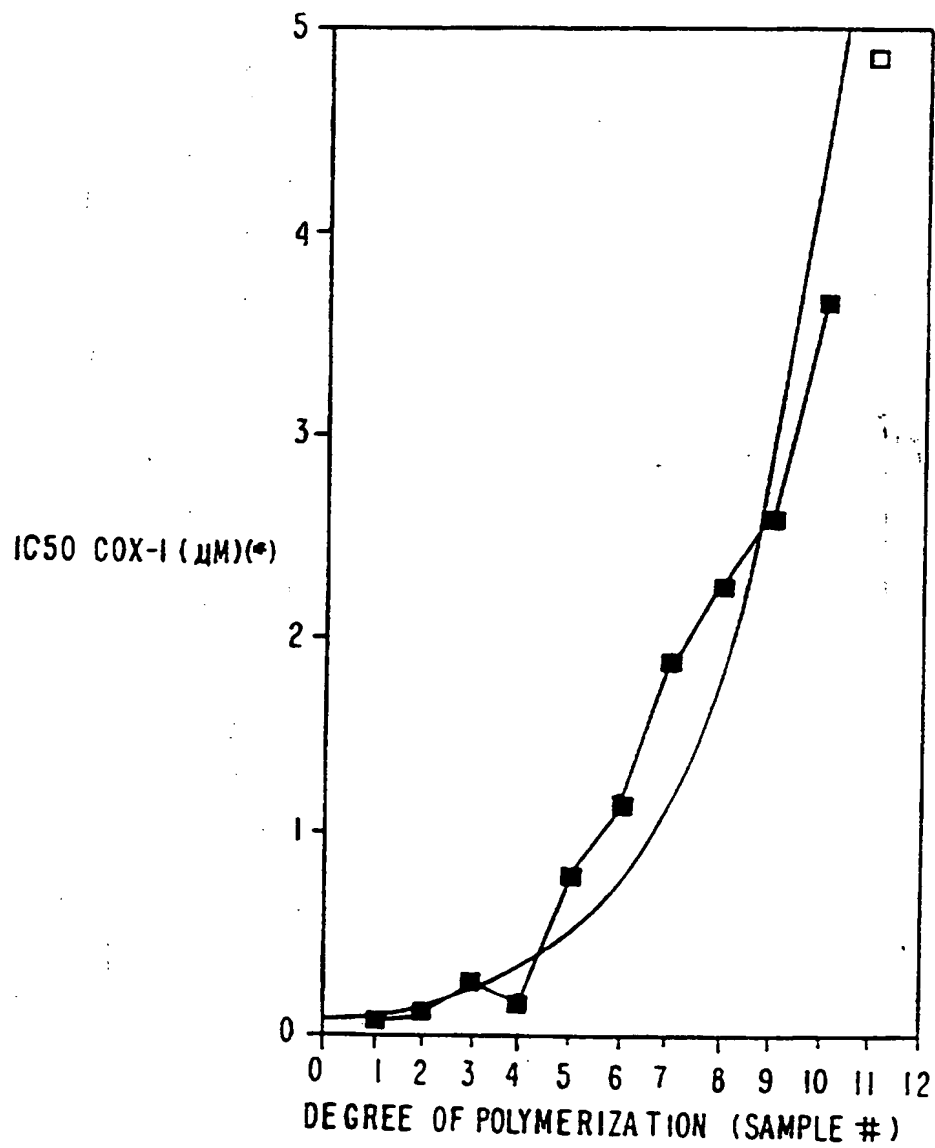
FIG. 33B





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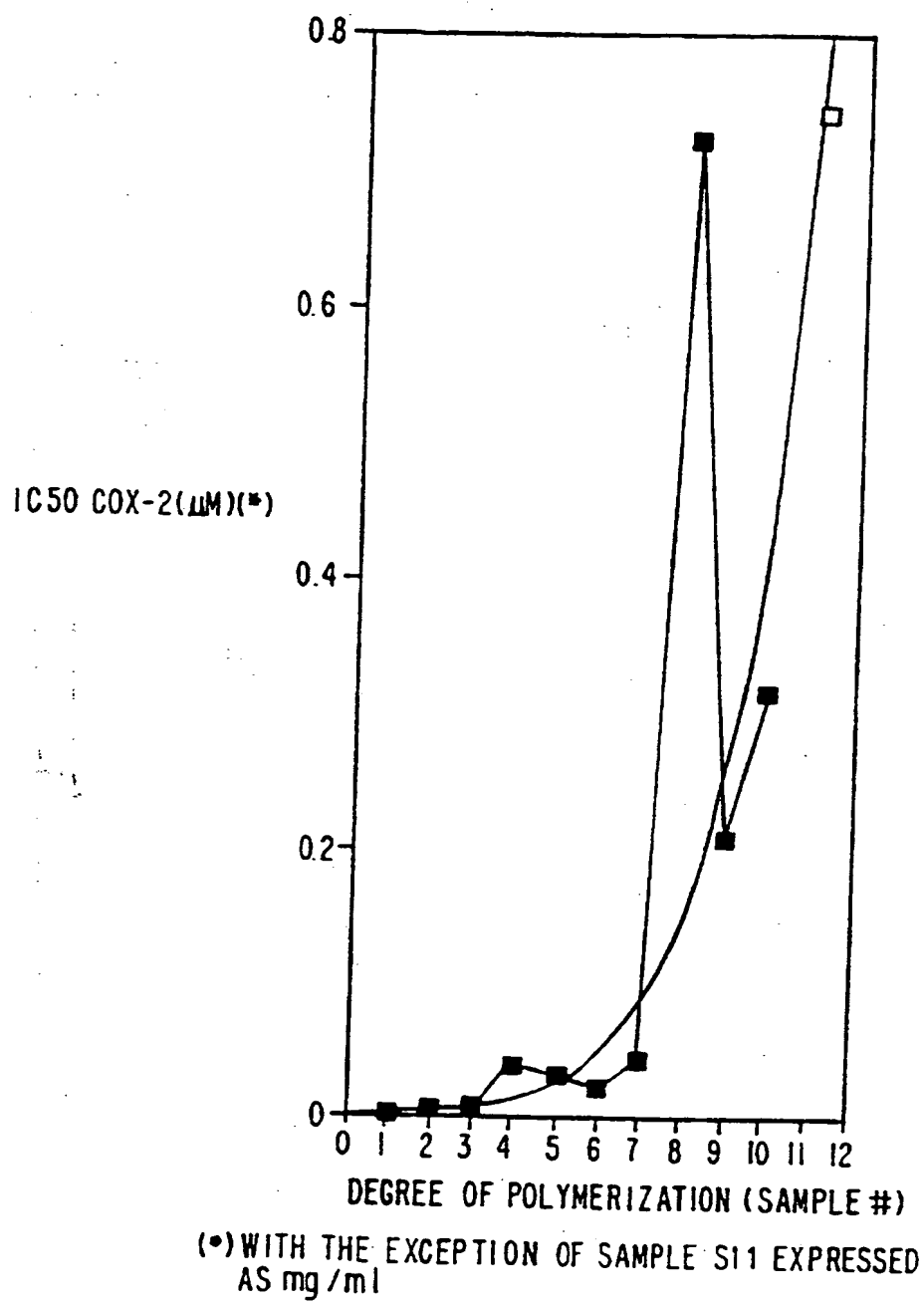
FIG. 34A



(\*) WITH THE EXCEPTION OF SAMPLE S11 EXPRESSED AS mg/ml

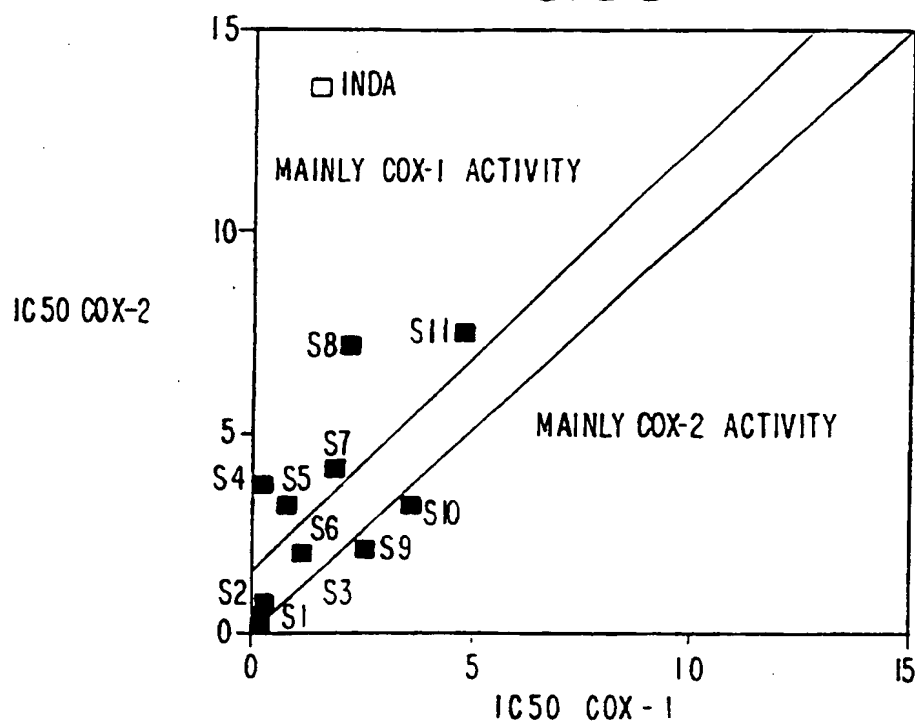
SUBSTITUTE SHEET (RULE 26)

FIG. 34B



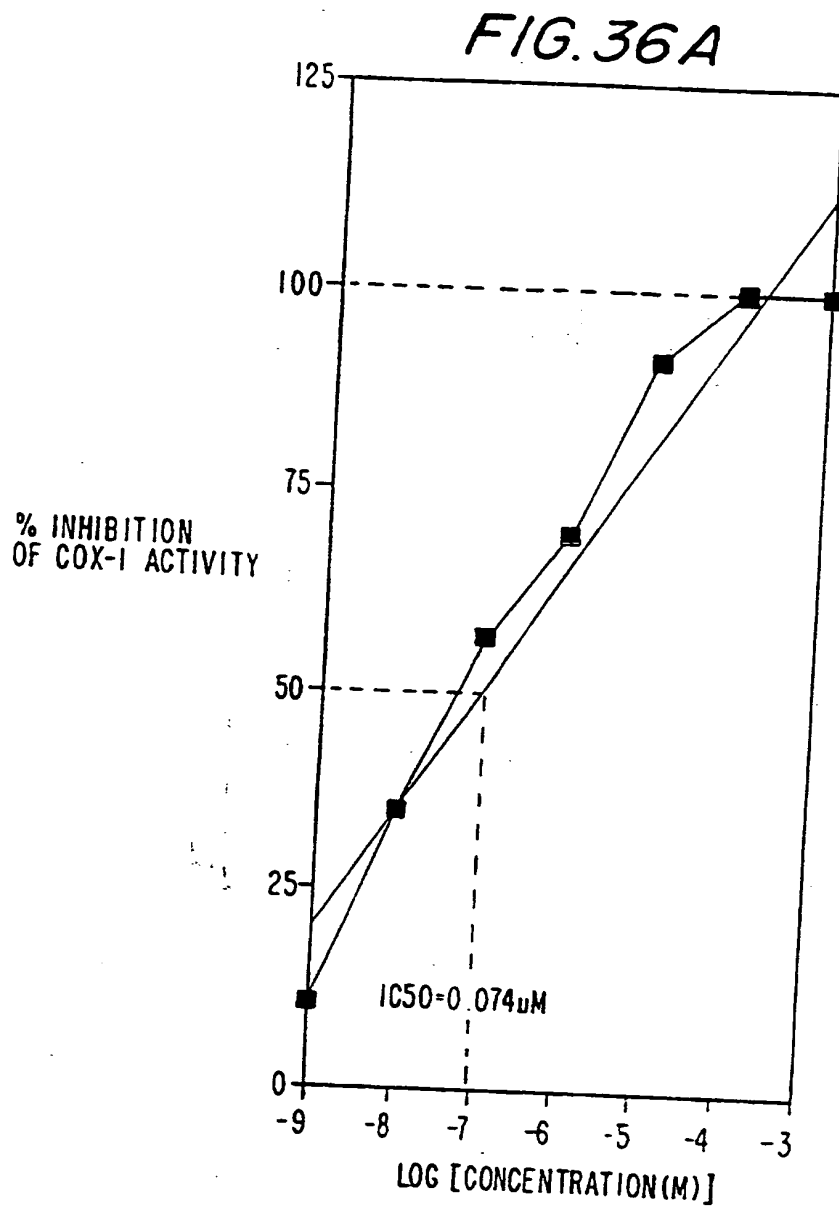
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FIG. 35



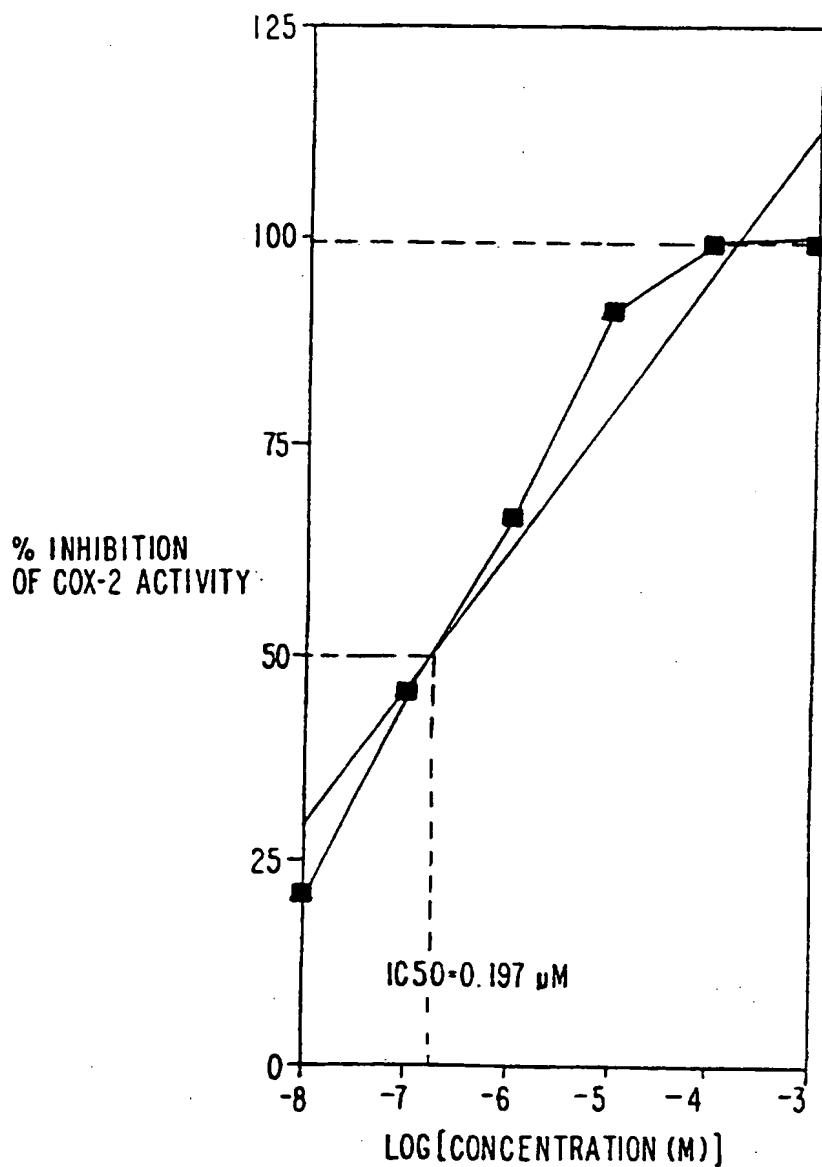
(•) WITH THE EXEPTION OF SAMPLE S11

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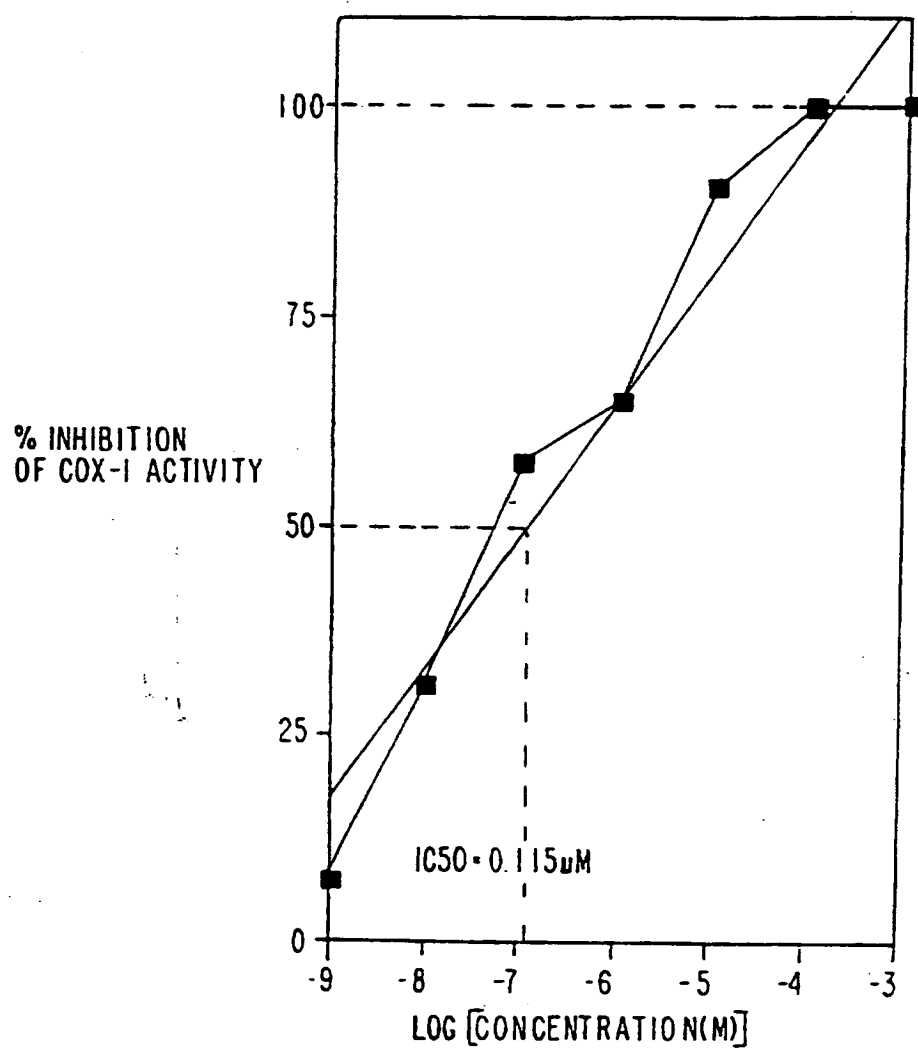
FIG. 36B



SUBSTITUTE SHEET (RULE 26)

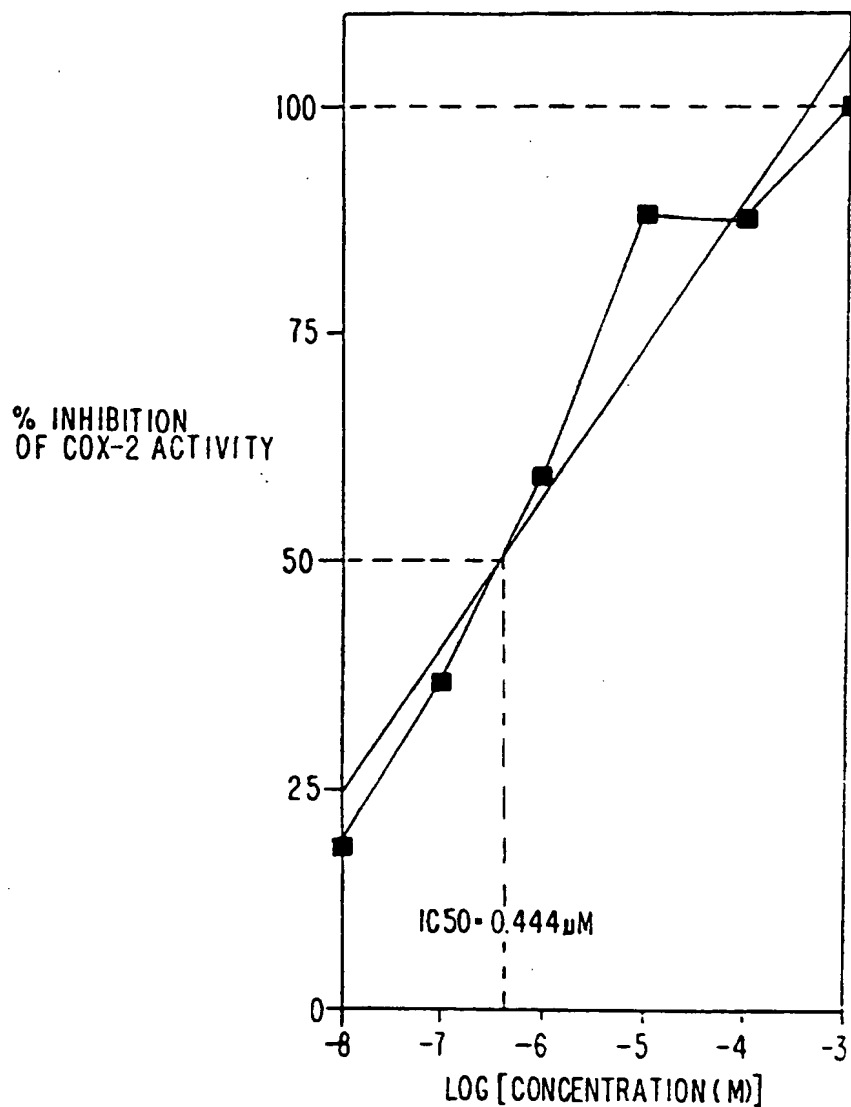
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FIG. 36C



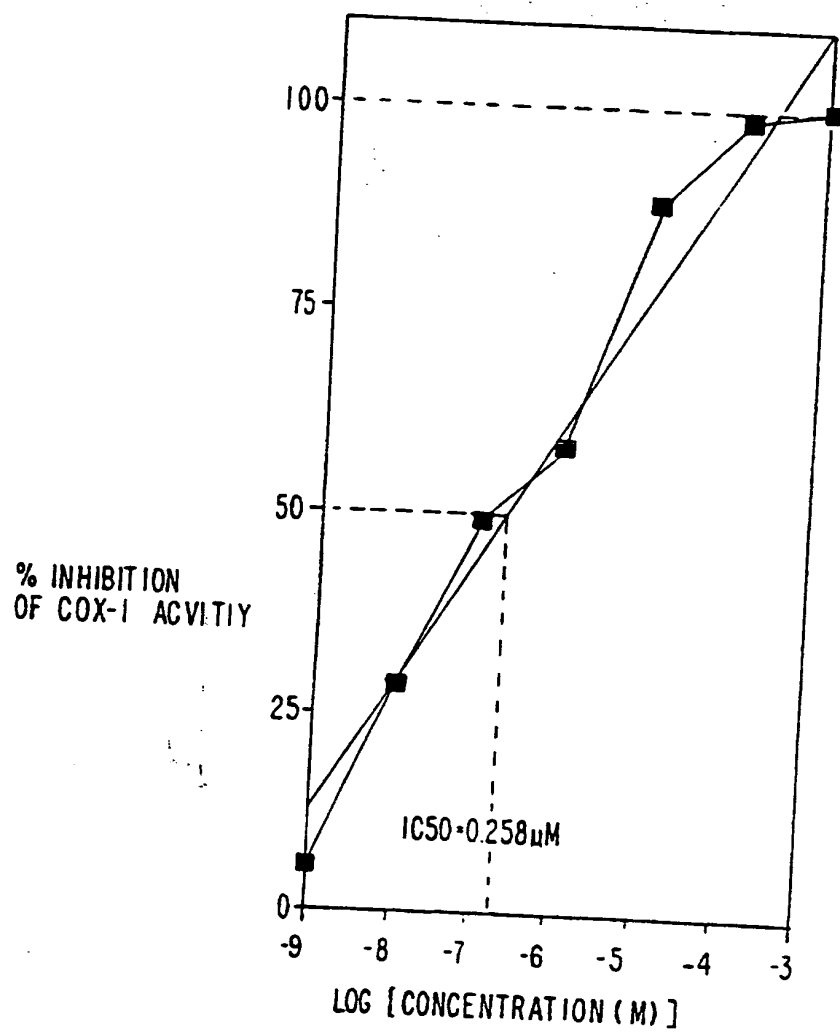
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FIG. 36D



SUBSTITUTE SHEET (RULE 26)

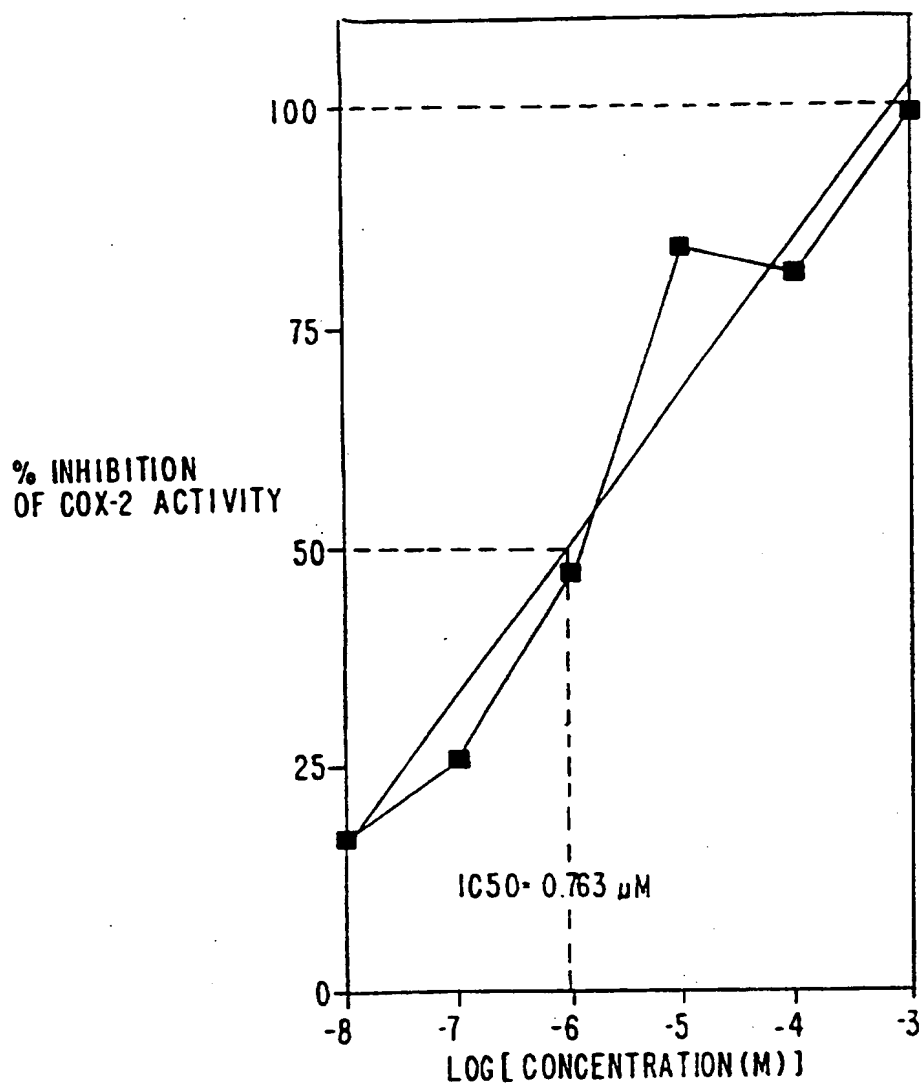
FIG. 36E





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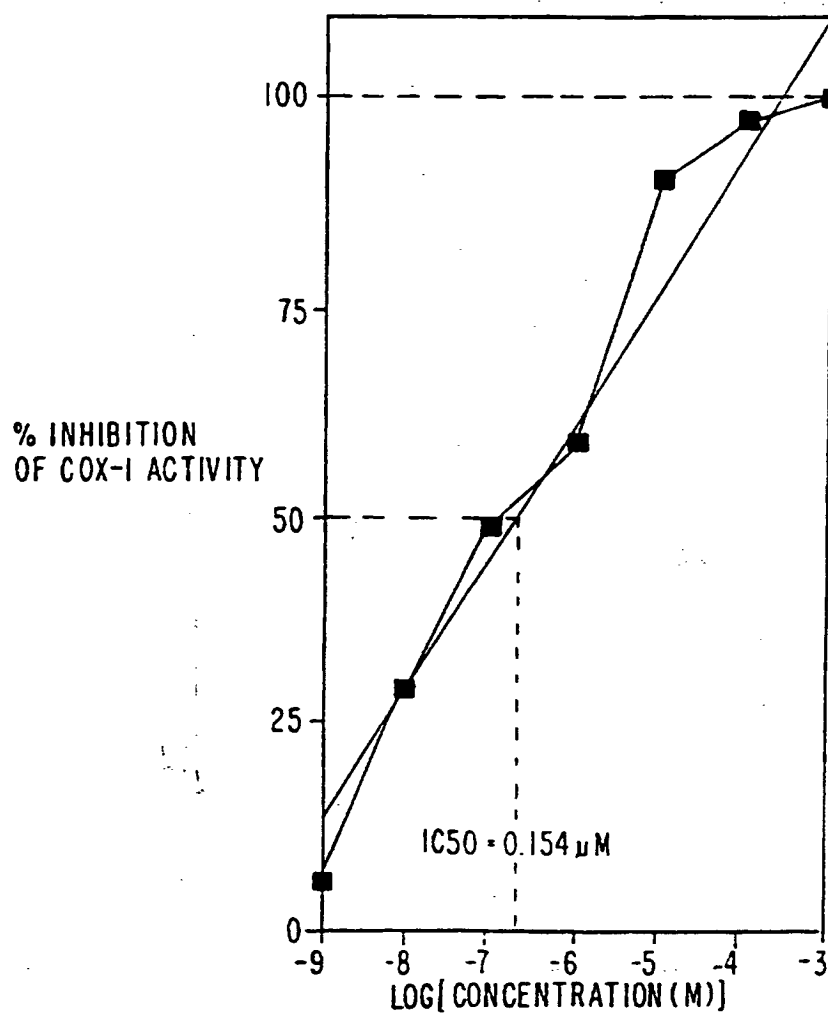
FIG. 36F



SUBSTITUTE SHEET (RULE 26)

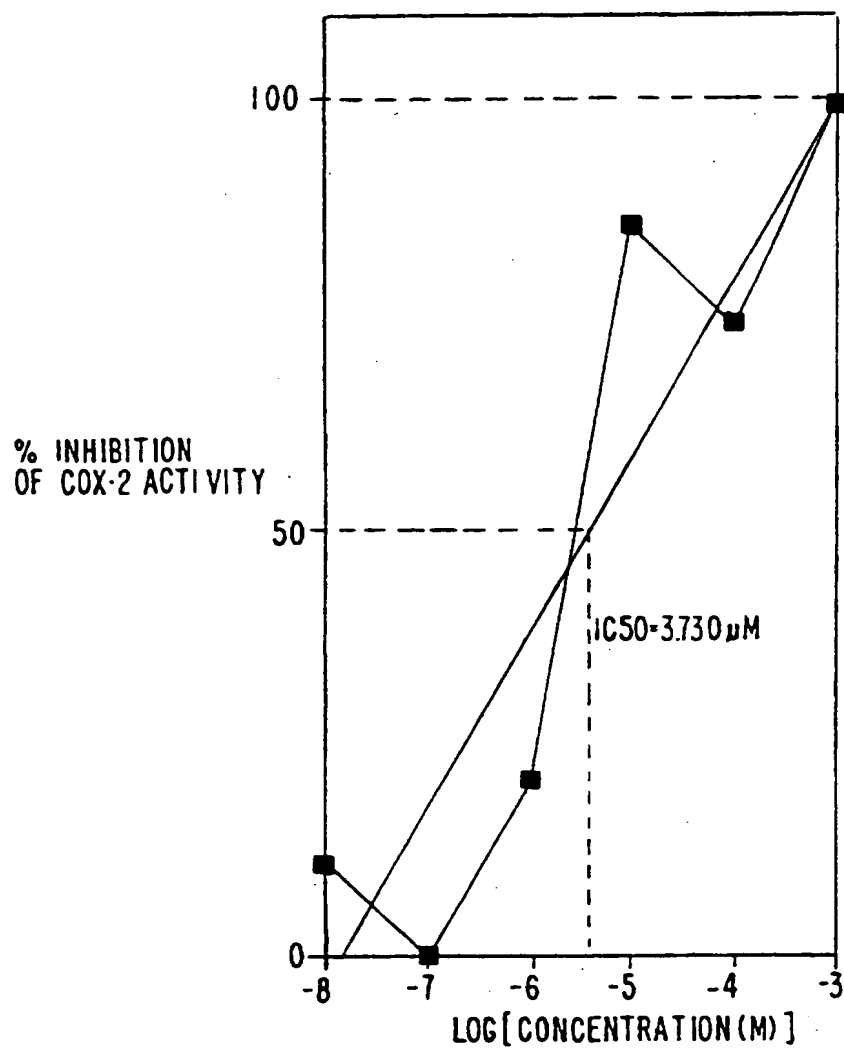
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FIG. 36G



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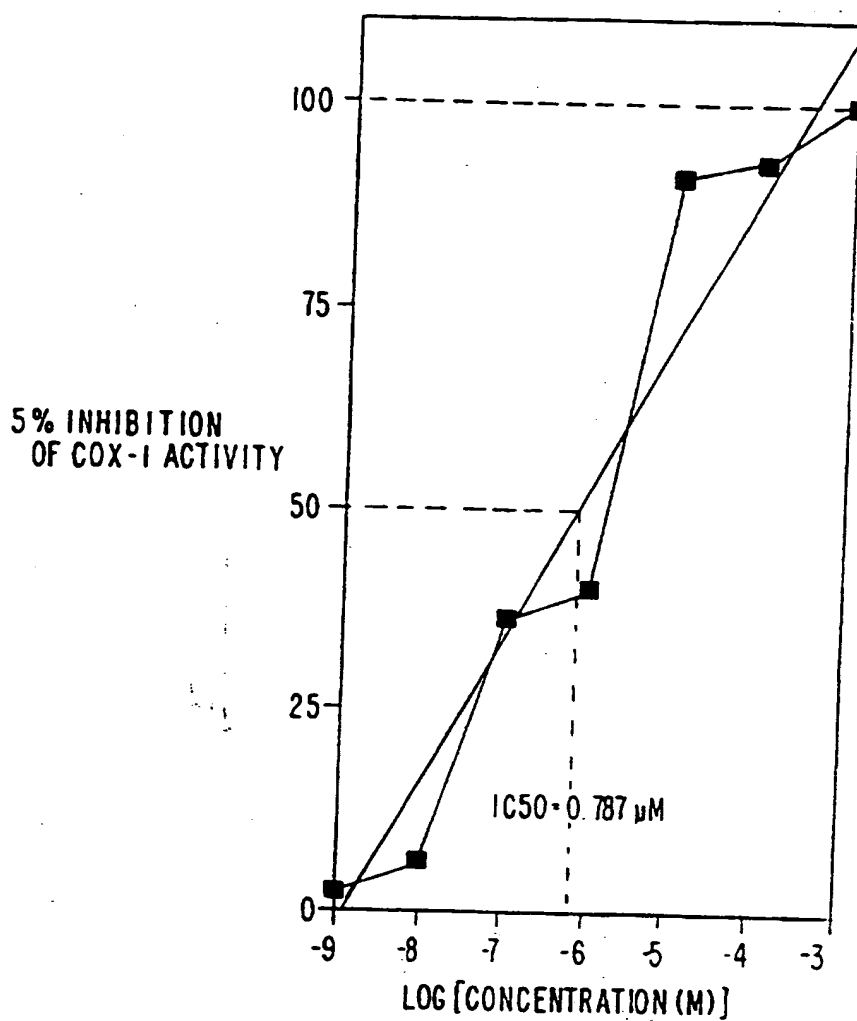
FIG. 36H



SUBSTITUTE SHEET (RULE 26)

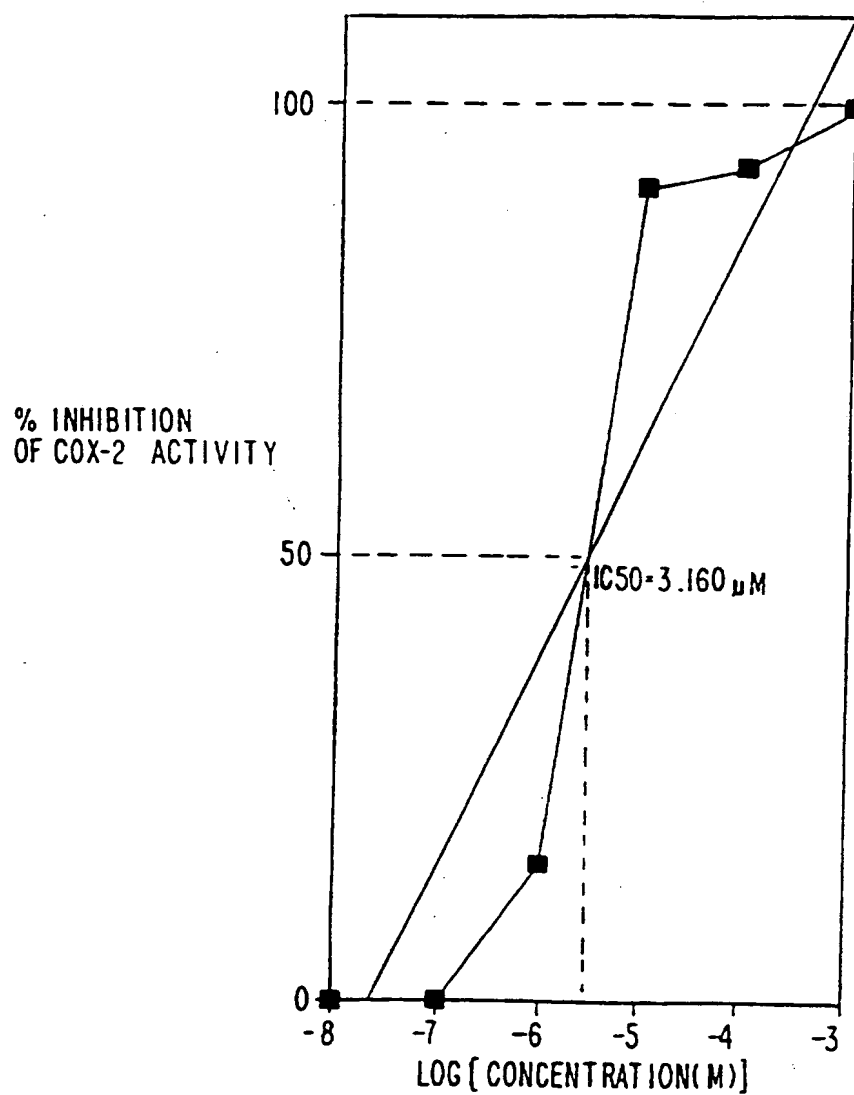
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FIG. 36I



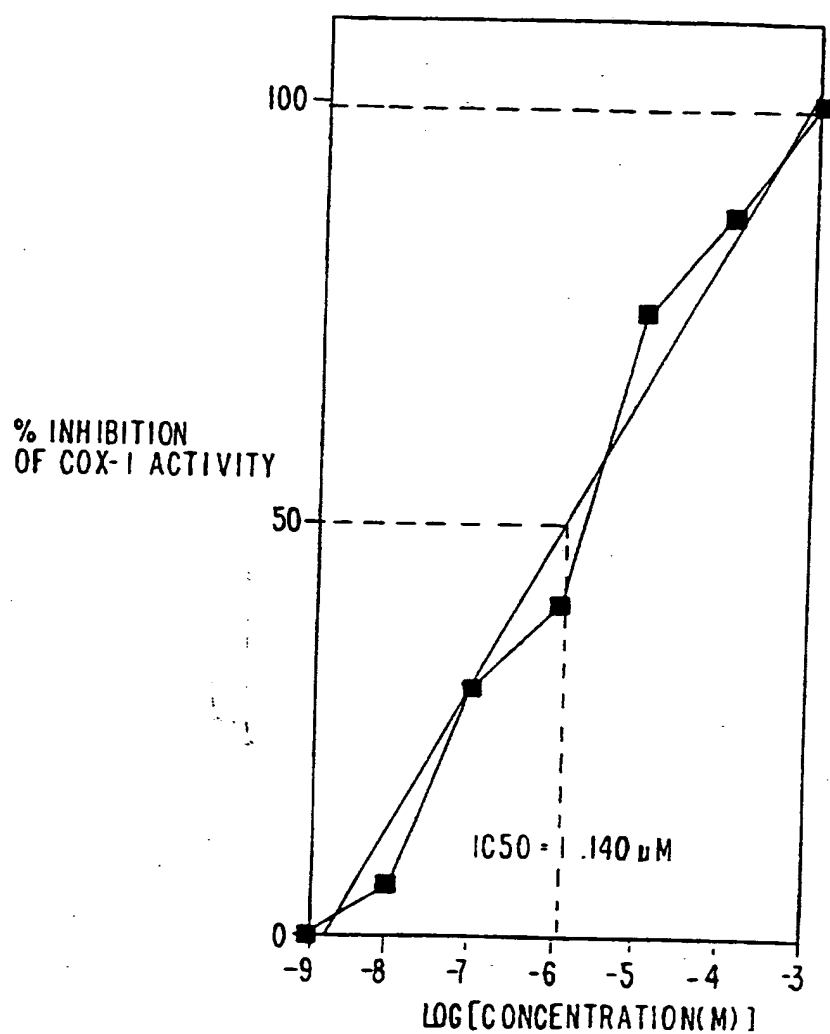
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FIG. 36J



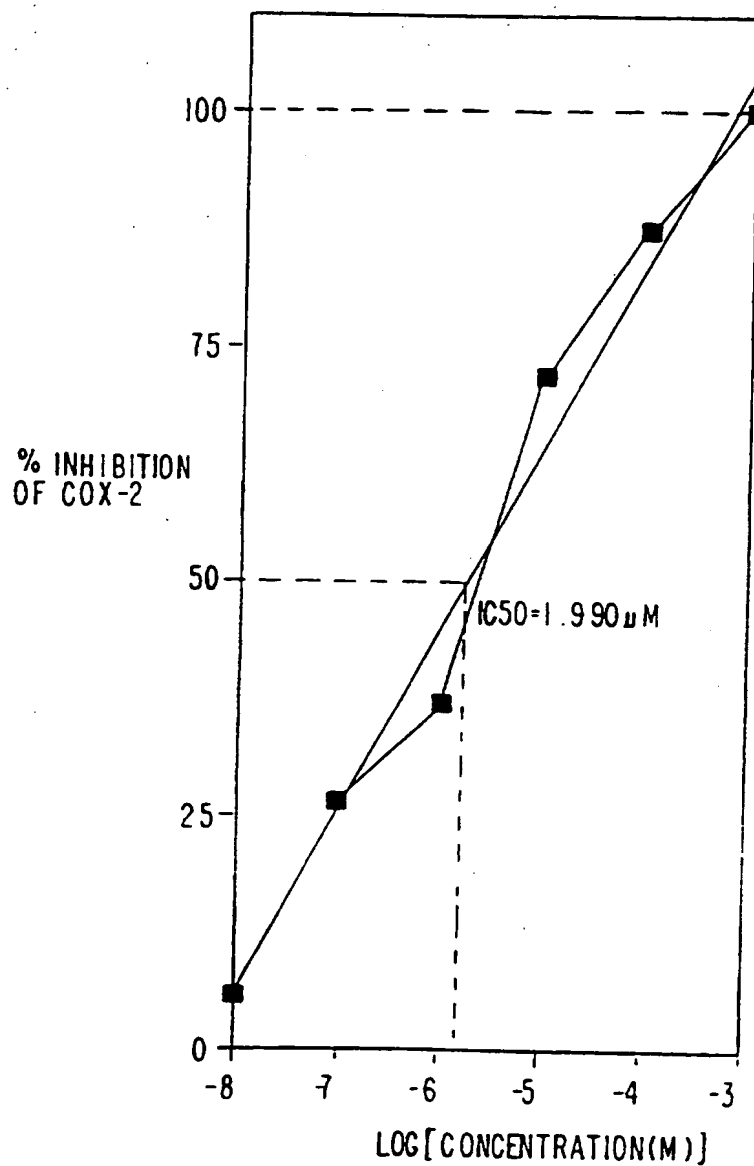
SUBSTITUTE SHEET (RULE 26)

FIG. 36K



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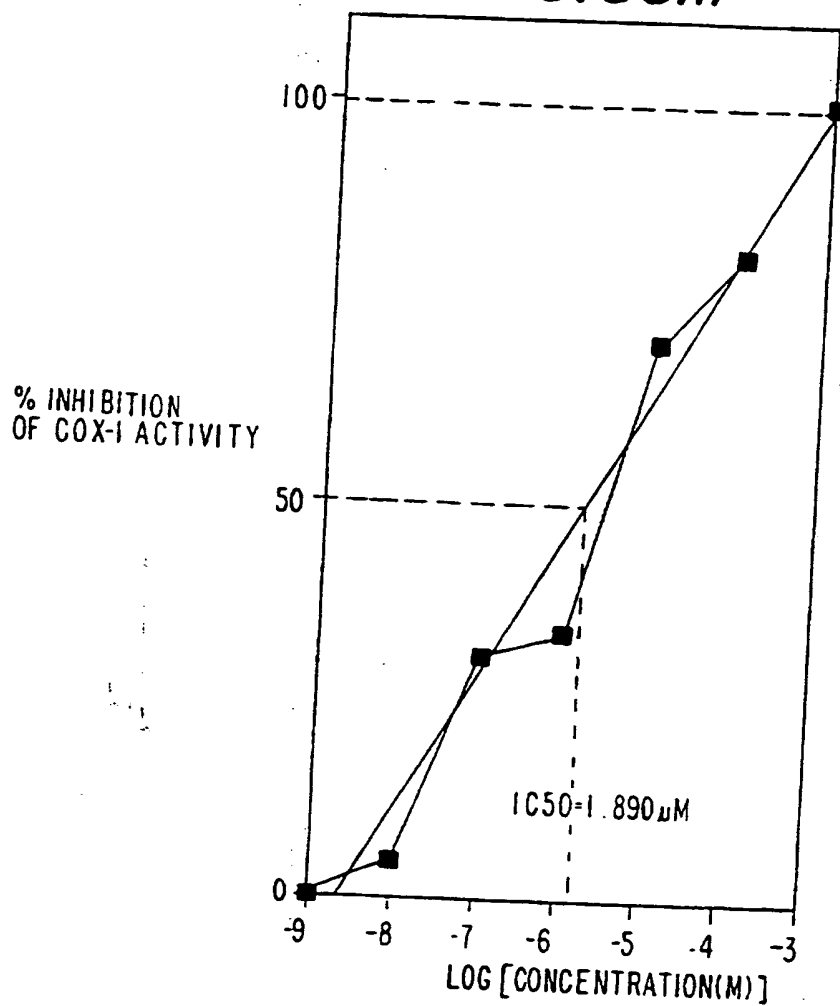
FIG. 36L



SUBSTITUTE SHEET (RULE 26)

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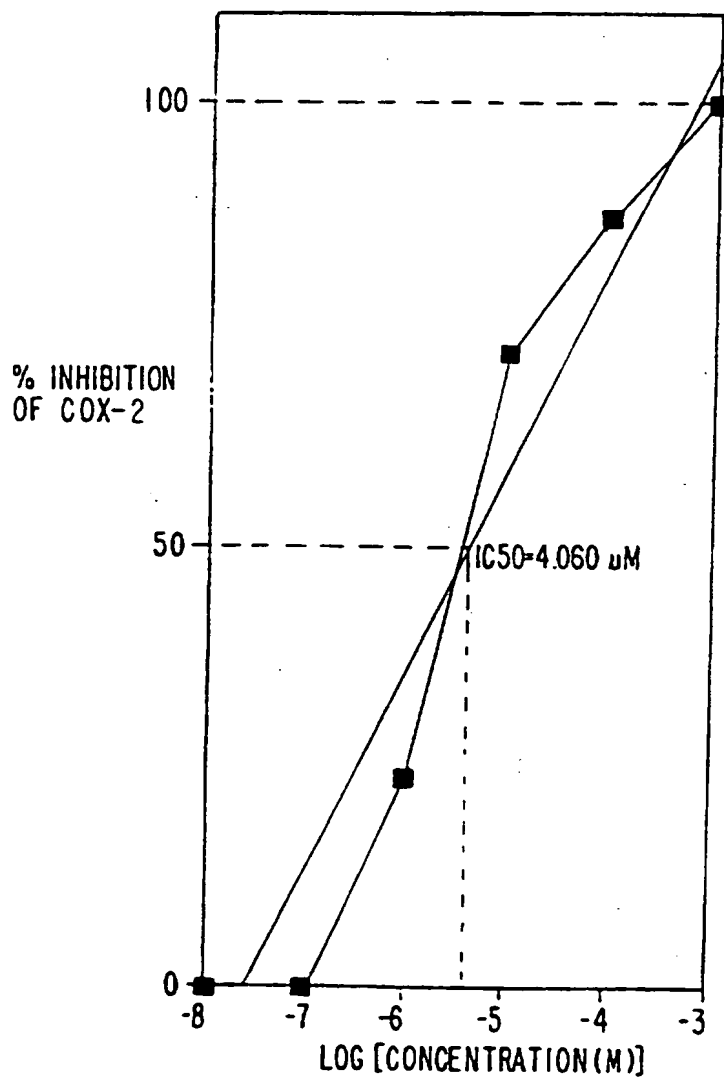
FIG. 36M





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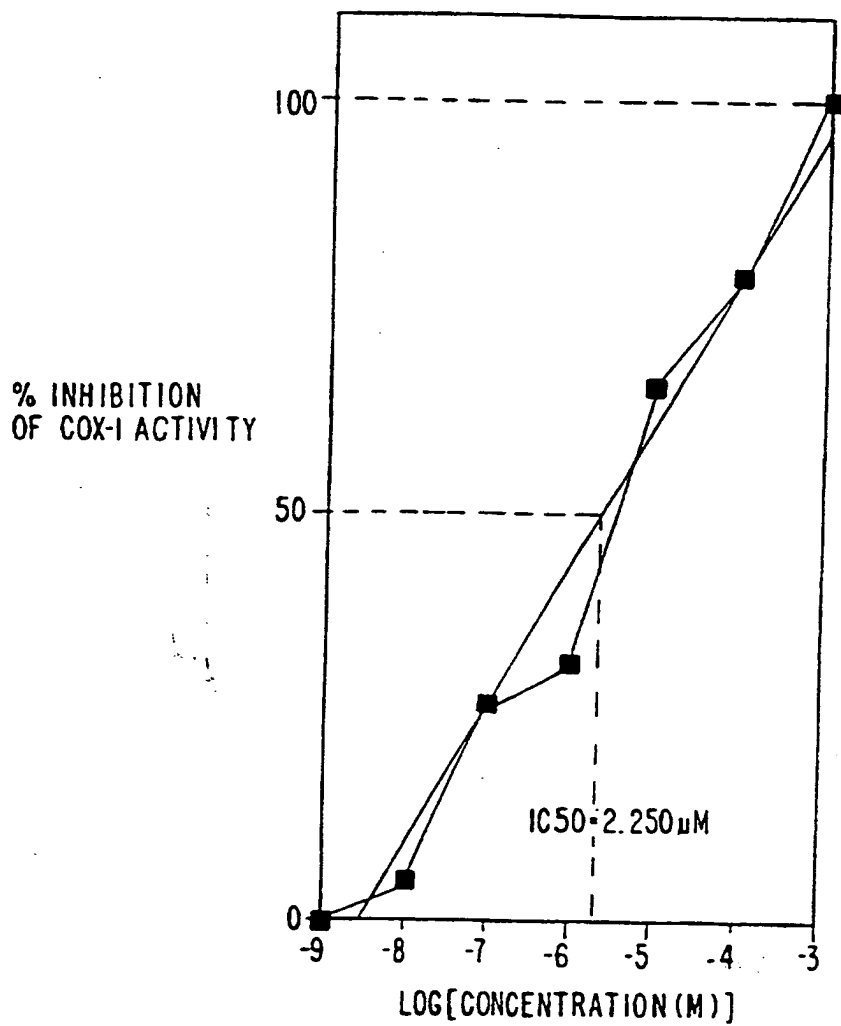
FIG. 36N



SUBSTITUTE SHEET (RULE 26)

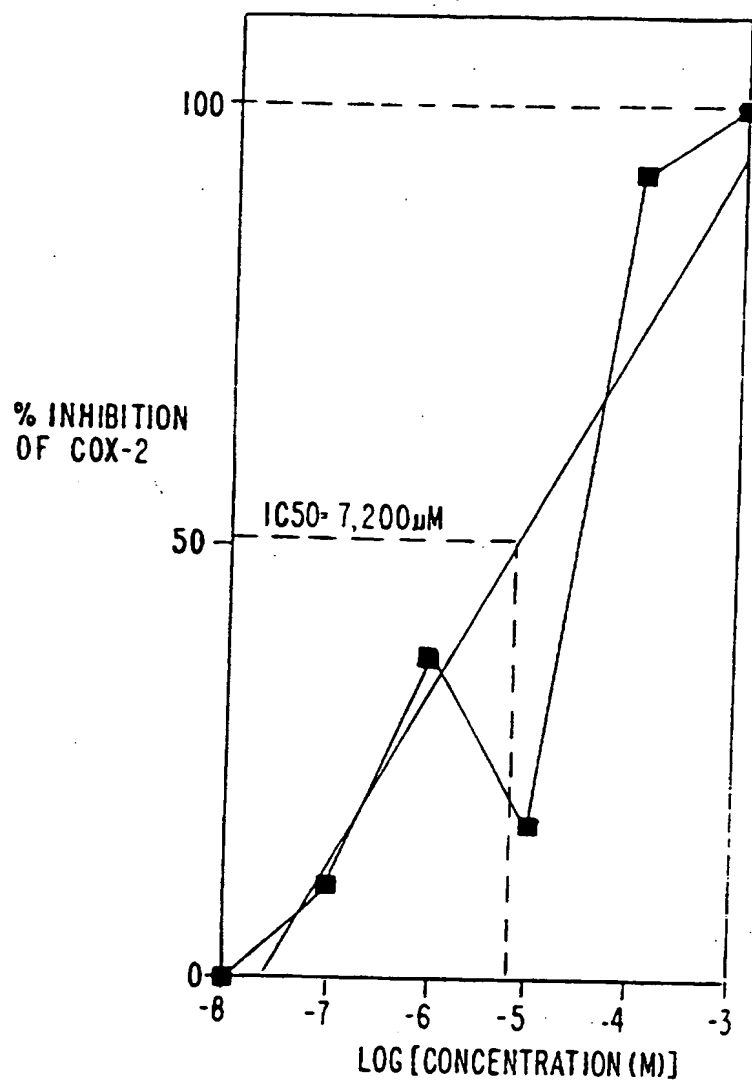
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FIG. 360



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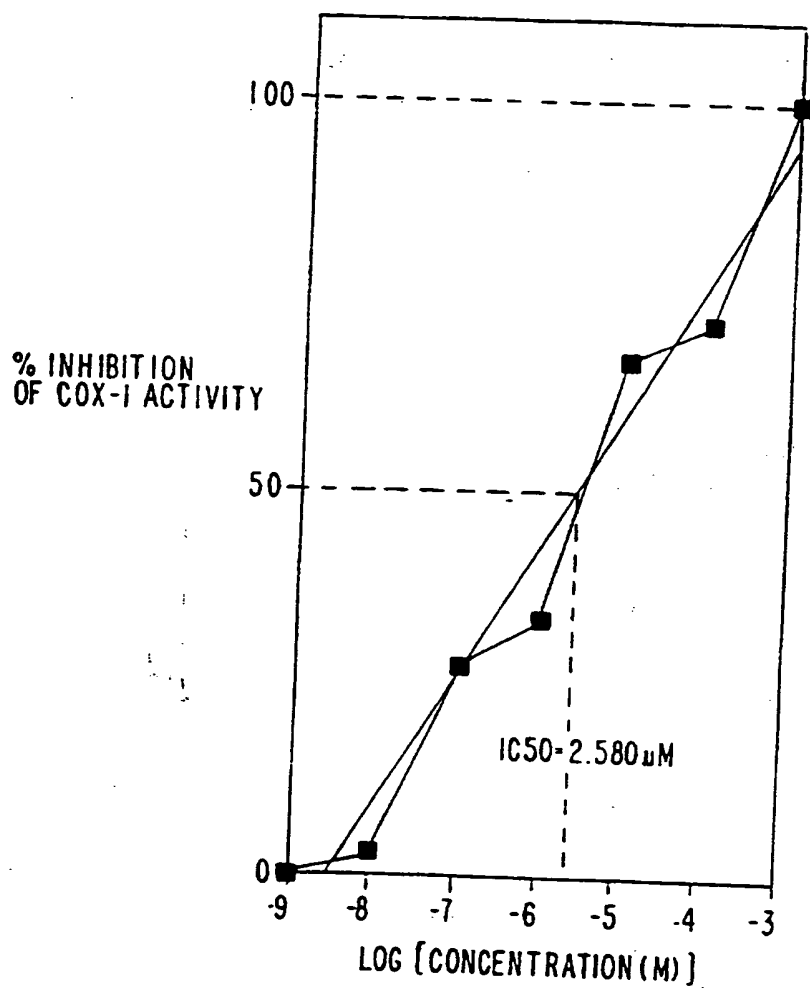
FIG. 36P



SUBSTITUTE SHEET (RULE 26)

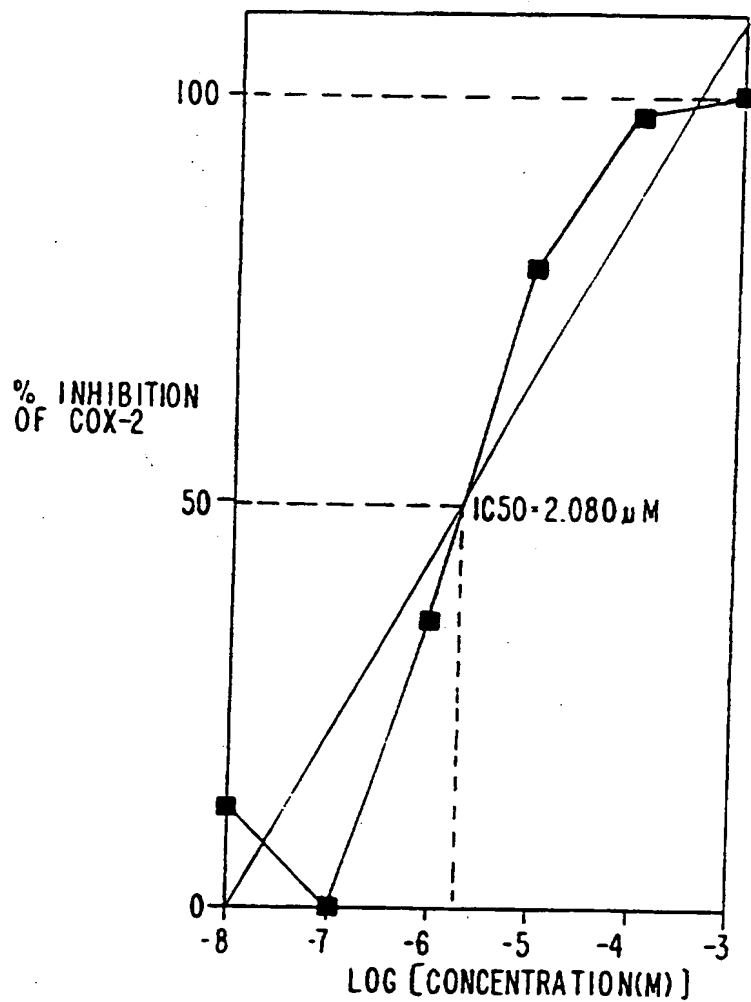
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FIG. 36Q



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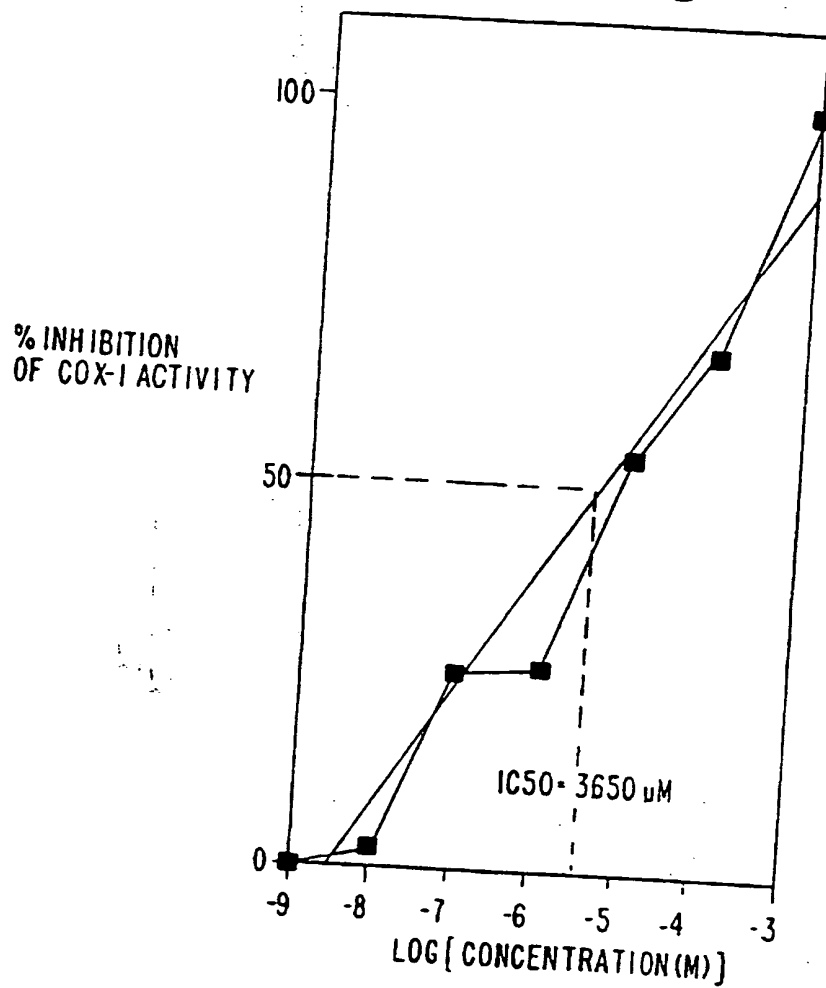
FIG. 36R



SUBSTITUTE SHEET (RULE 26)

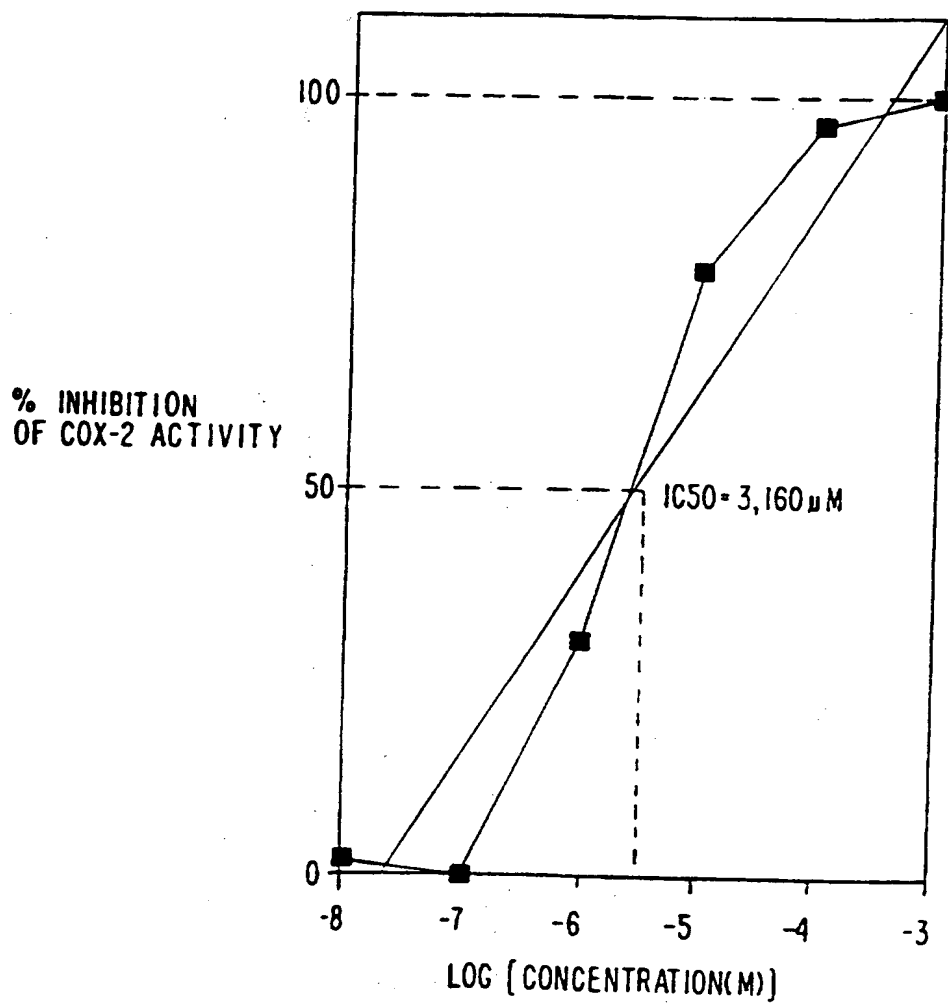
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FIG. 36S



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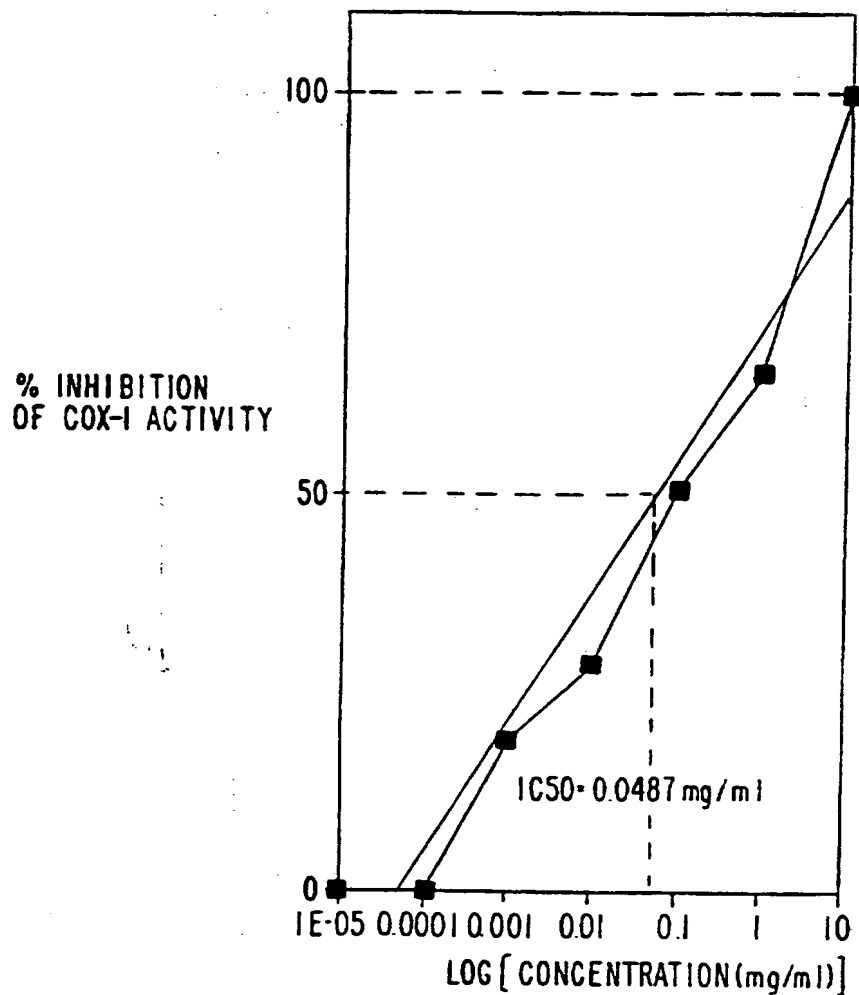
FIG. 36T



SUBSTITUTE SHEET (RULE 26)

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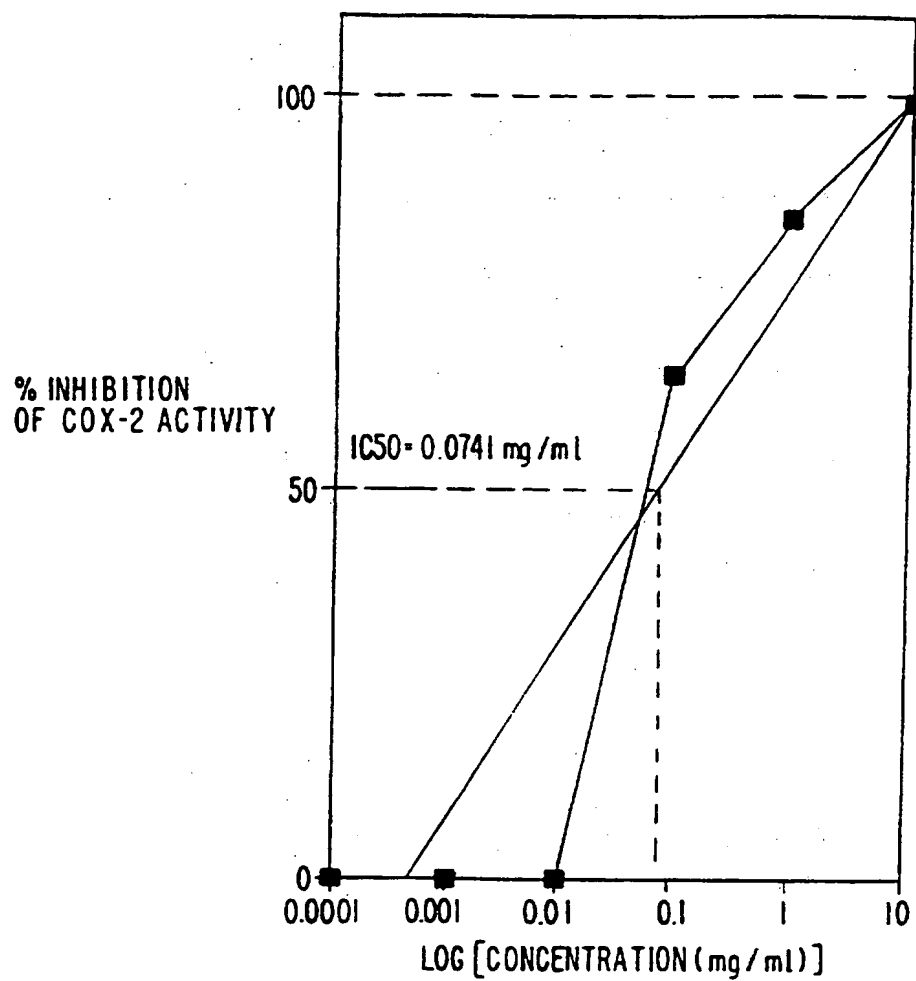
FIG. 36U





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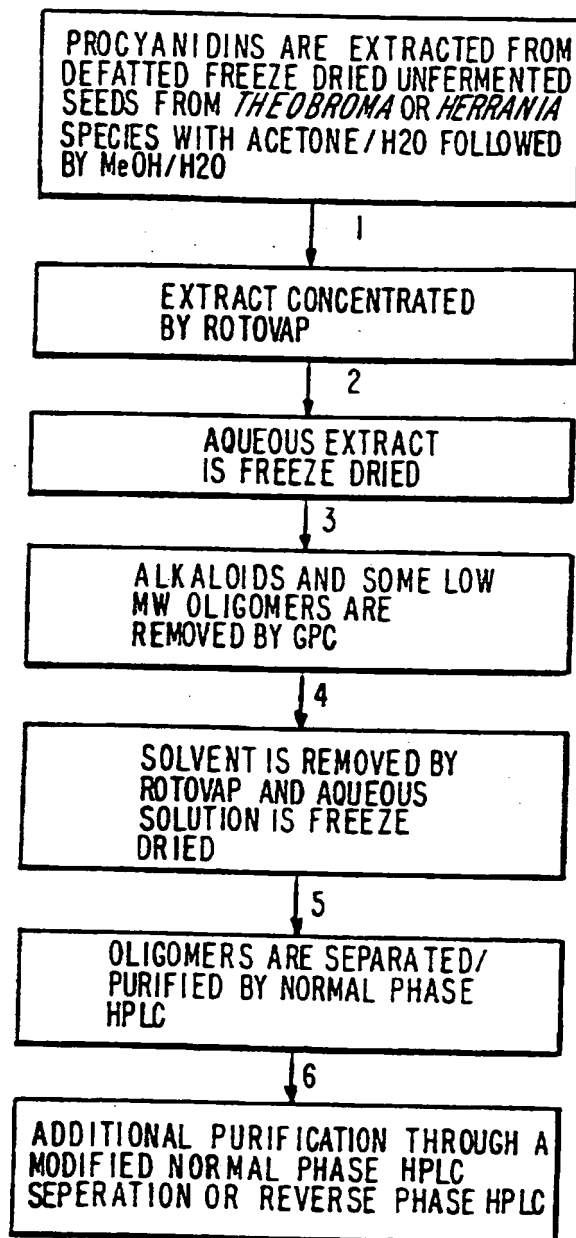
FIG. 36V



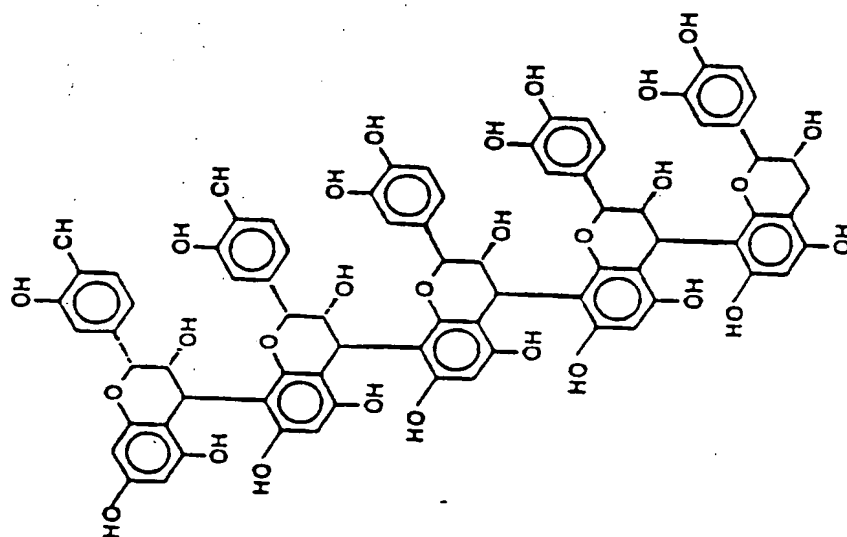
SUBSTITUTE SHEET (RULE 26)

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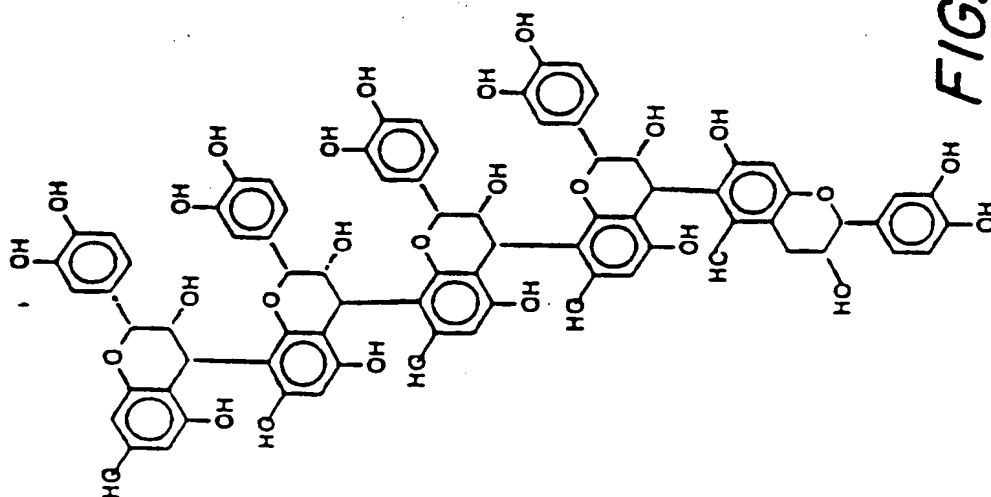
FIG. 37



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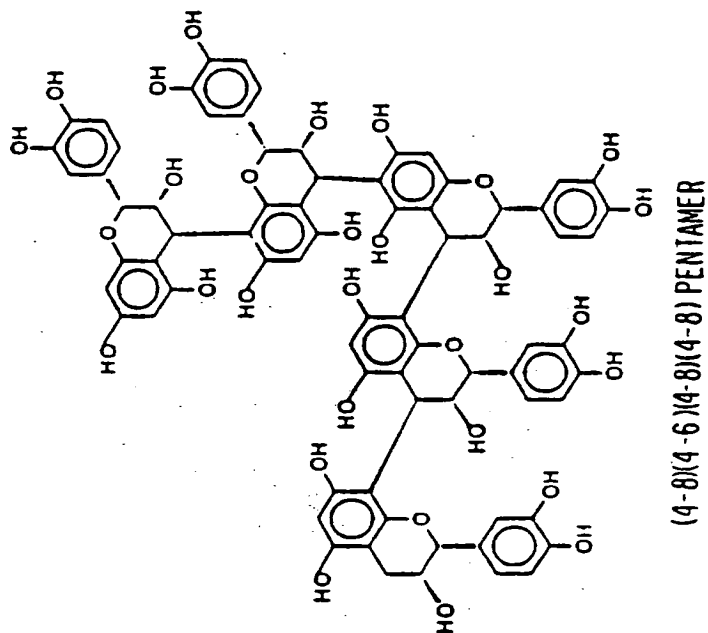


**FIG. 38B**  
(4-8)(4-8)(4-8)(4-6) CENTAMER



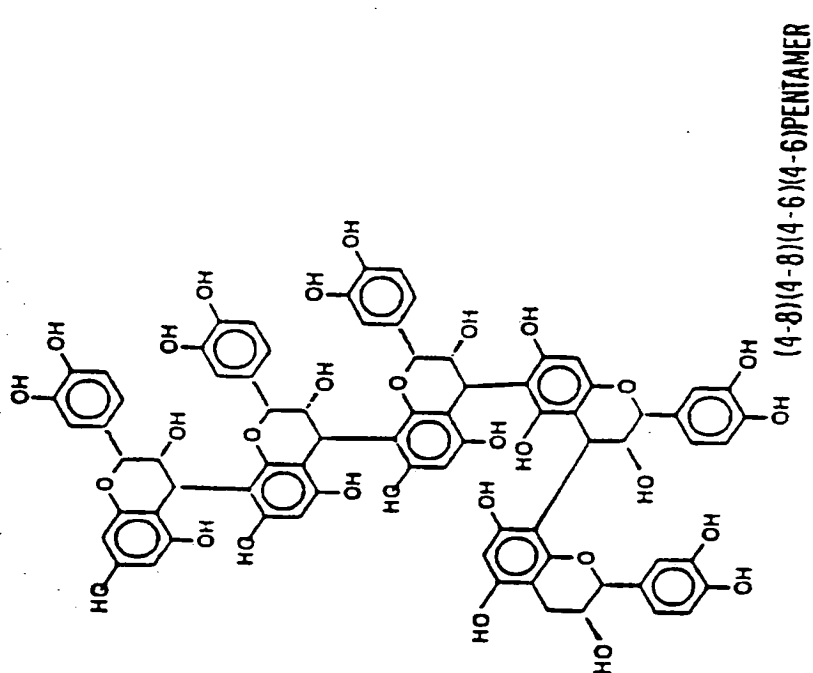
**FIG. 38A**  
(4-8)(4-8)(4-8X4-6) PENTAMER

SUBSTITUTE SHEET (RULE 26)



(4-8)(4-6)(4-8)(4-8)PENTAMER

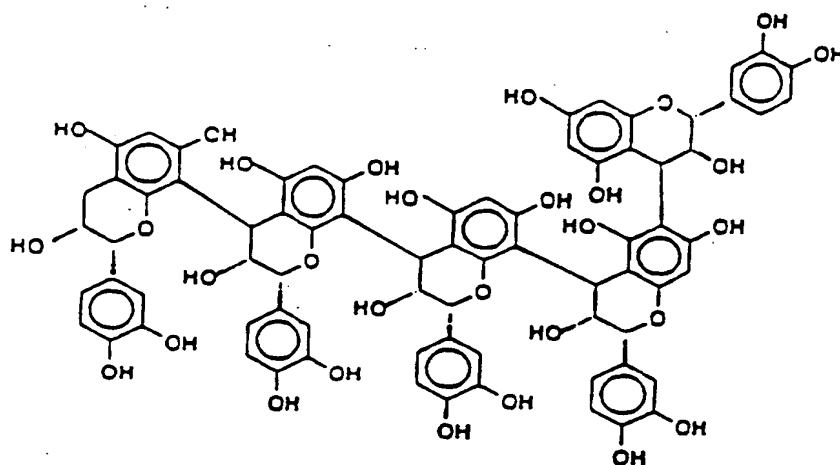
FIG. 38D



(4-8)(4-8)(4-6)(4-6)PENTAMER

FIG. 38C

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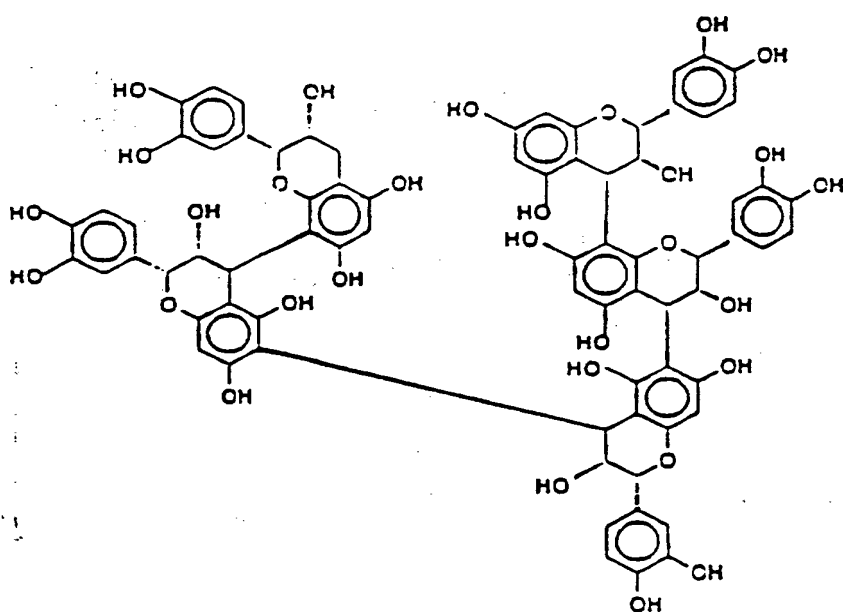


(4-6)(4-8)(4-8)(4-8) PENTAMER

*FIG. 38E*

SUBSTITUTE SHEET (RULE 26)

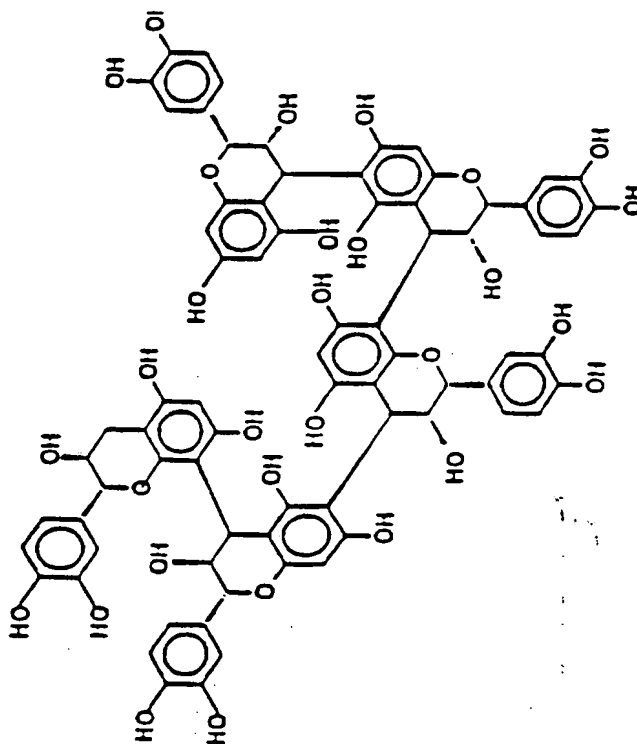
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(4-8)(4-6x4-6)(4-8) PENTAMER

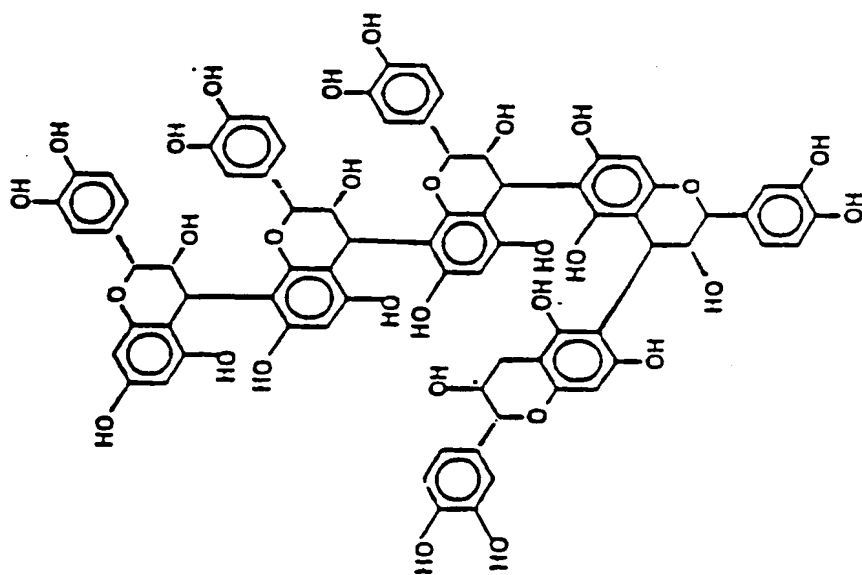
*FIG. 38F*

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(4-6)(4-8)(4-6)(4-8)PENTAMER

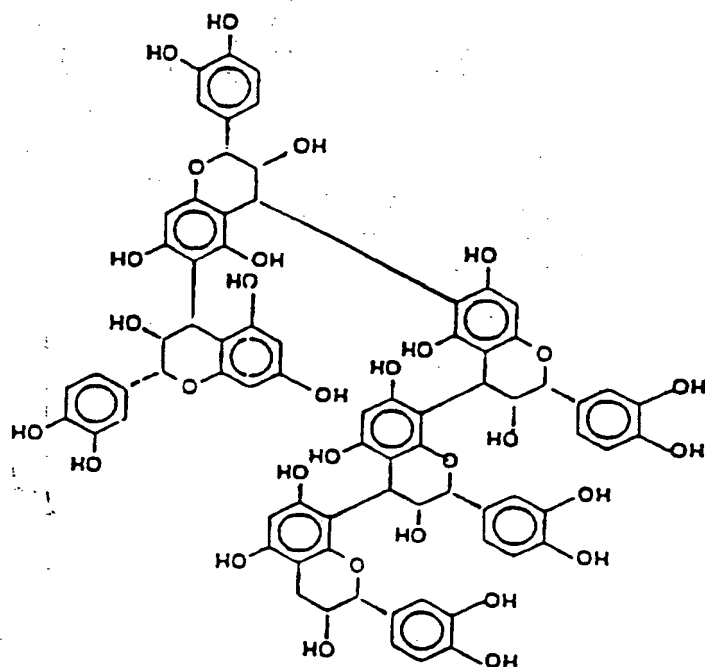
FIG. 38H



(4-8)(4-8)(4-6)(4-6)PENTAMER

FIG. 38G

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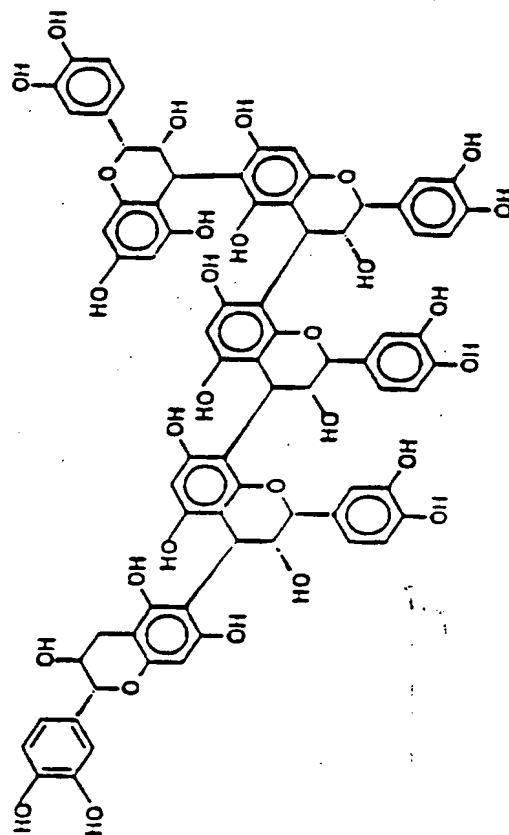


(4-6)(4-6)(4-8)(4-8)PENTAMER

FIG. 38I

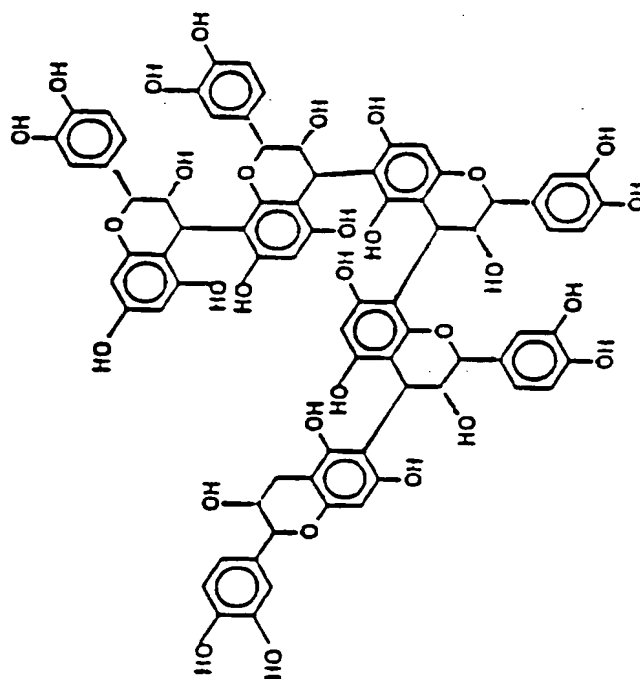


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(4-6)(4-8)(4-8)(4-6) PENTAMER

FIG. 38K

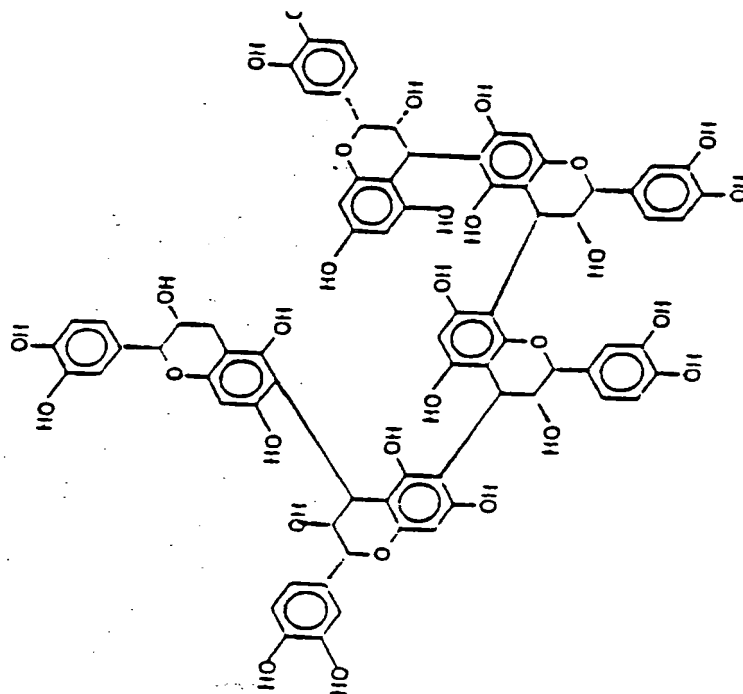


(4-8)(4-6)(4-8)(4-6) PENTAMER

FIG. 38J

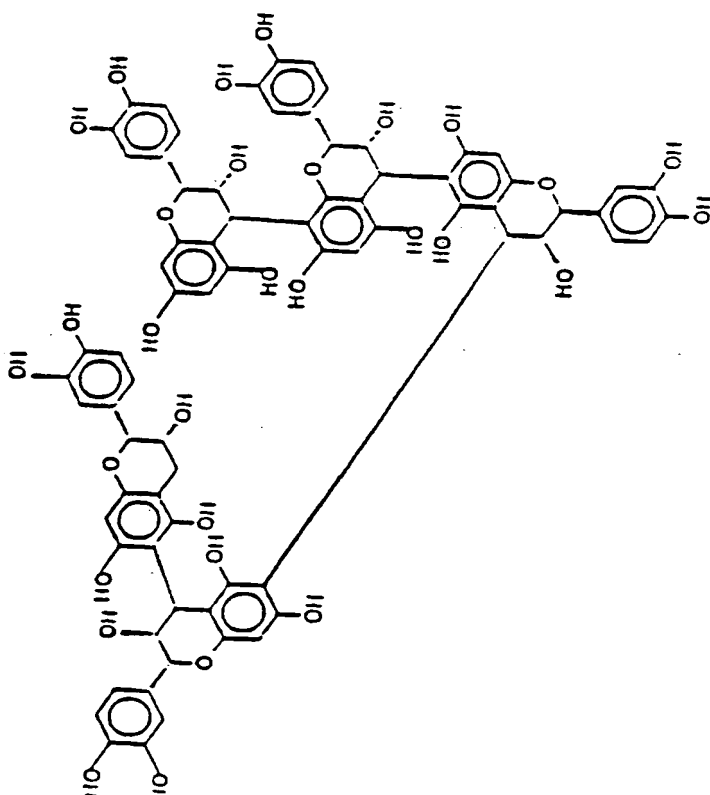
SUBSTITUTE SHEET (RULE 26)

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(4-6)(4-8)(4-6)(4-6)PENTAMER

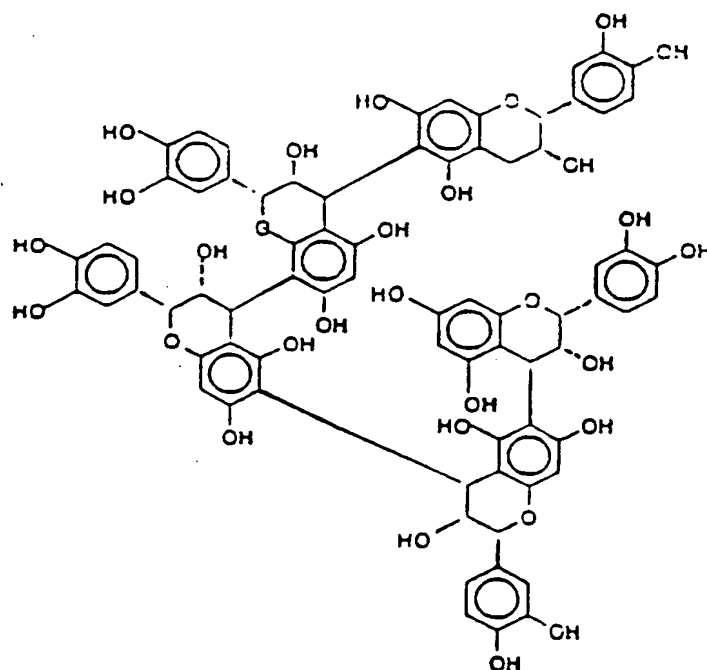
FIG. 38M



(4-8)(4-6)(4-6)(4-6)PENTAMER

FIG. 38L

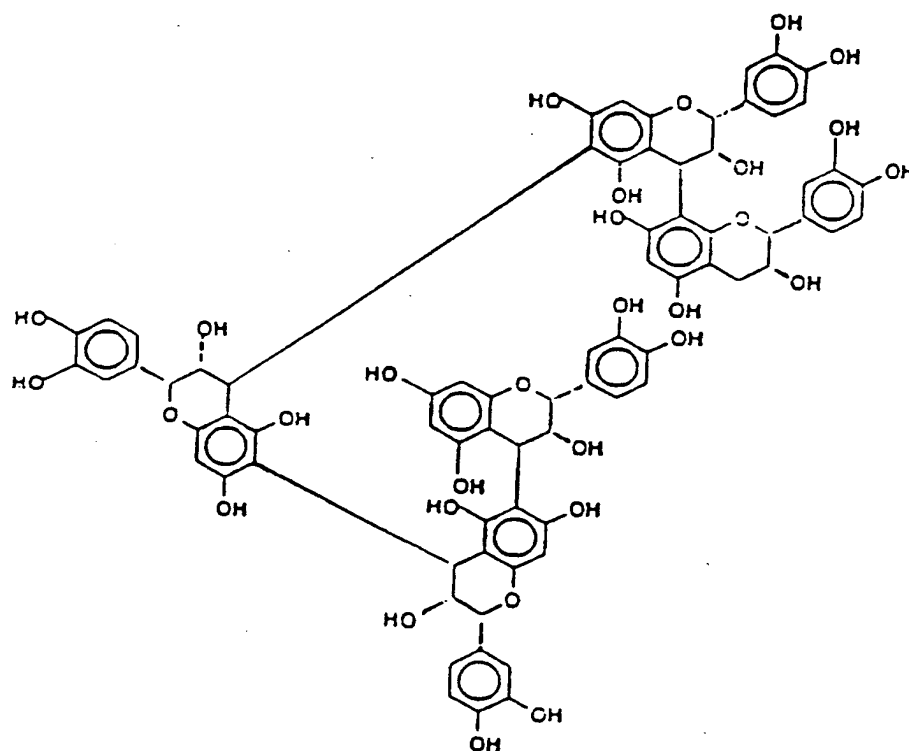
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(4-6)(4-6)(4-8)(4-6)PENTAMER

FIG. 38N

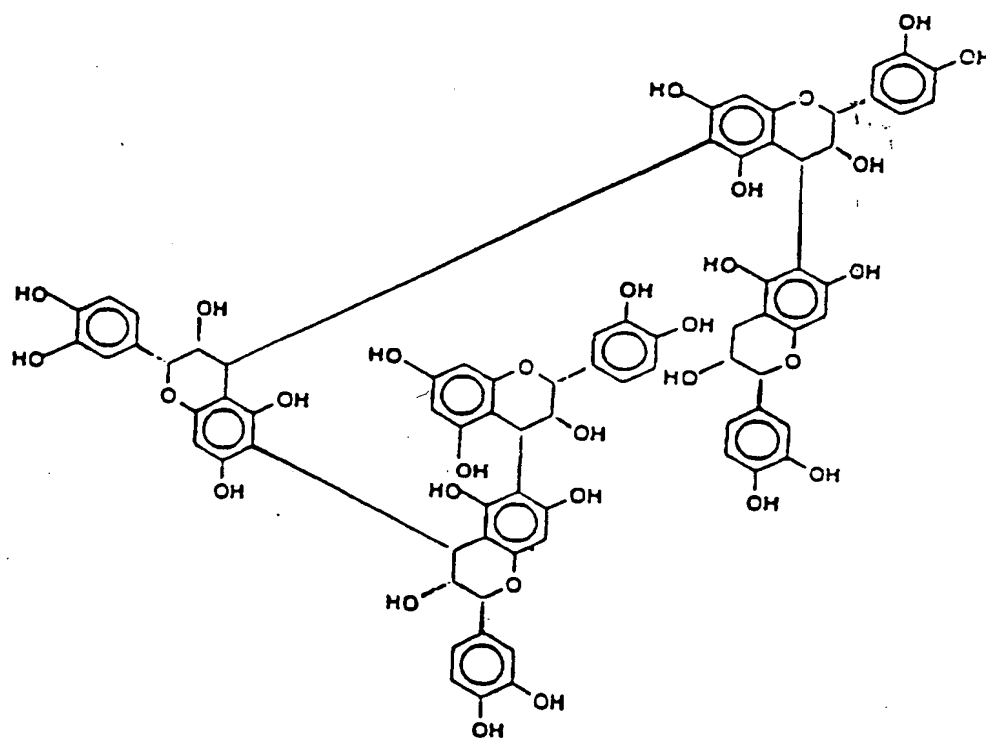
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(4-6)(4-6)(4-6)(4-6) PENTAMER

FIG. 380

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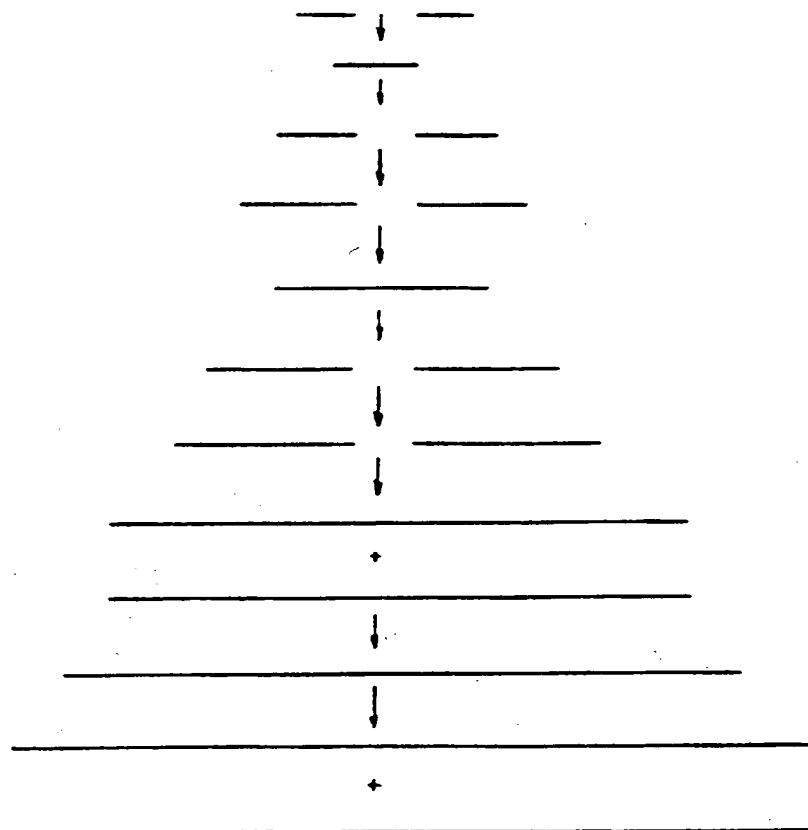
(4-6)(4-6)(4-6)(4-8)PENTAMER

FIG. 38P

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FIG. 39A



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X-CAT  
0-EC

(CONTINUE LEVEL V)

FIG. 39AA

0-X-X-X-0	(4-8; 4-8; 4-8; 4-6)
0-X-X-X-0	(4-8; 4-8; 4-8; 4-8)
X-X-X-X-0	(4-6; 4-6; 4-6; 4-6)
X-X-X-X-0	(4-6; 4-6; 4-6; 4-8)
X-X-X-X-0	(4-6; 4-6; 4-8; 4-6)
X-X-X-X-0	(4-6; 4-6; 4-8; 4-8)
X-X-X-X-0	(4-6; 4-6; 4-6; 4-6)
X-X-X-X-0	(4-6; 4-8; 4-6; 4-8)
X-X-X-X-0	(4-6; 4-8; 4-8; 4-6)
X-X-X-X-0	(4-6; 4-8; 4-8; 4-8)
X-X-X-X-0	(4-8; 4-6; 4-6; 4-6)
X-X-X-X-0	(4-8; 4-6; 4-6; 4-8)
X-X-X-X-0	(4-8; 4-6; 4-8; 4-6)
X-X-X-X-0	(4-8; 4-8; 4-6; 4-6)
X-X-X-X-0	(4-8; 4-8; 4-6; 4-8)
X-X-X-X-0	(4-8; 4-8; 4-8; 4-6)

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X-CAT  
O-EC

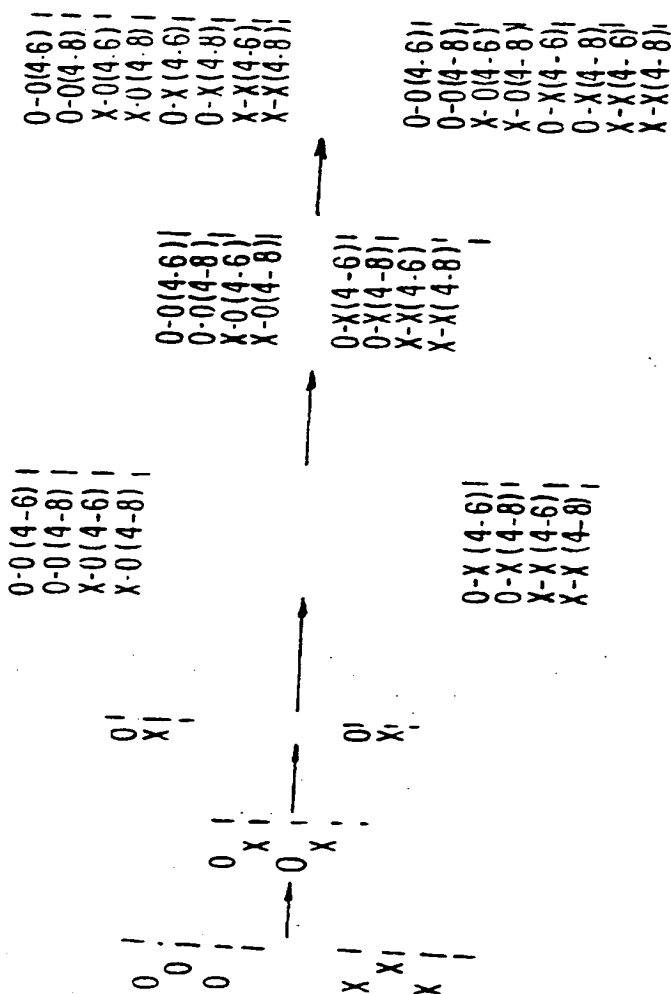


FIG. 39B  
LEVEL I



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X-CAT  
O-EC

(LEVEL I)

FIG. 39C

0-0-0 (4-6;4-6);  
0-0-0 (4-6;4-8);  
0-0-0 (4-8;4-6);  
0-0-0 (4-8;4-8);  
X-0-0 (4-6;4-6);  
X-0-0 (4-6;4-8);  
X-0-0 (4-8;4-6);  
X-0-0 (4-8;4-8);  
0-X-0 (4-6;4-6);  
0-X-0 (4-6;4-8);  
0-X-0 (4-8;4-6);  
0-X-0 (4-8;4-8);  
X-X-0 (4-6;4-6);  
X-X-0 (4-6;4-8);  
X-X-0 (4-8;4-6);  
X-X-0 (4-8;4-8);

0-0-X (4-6;4-6);  
0-0-X (4-6;4-8);  
0-0-X (4-8;4-6);  
0-0-X (4-8;4-8);  
X-0-X (4-6;4-6);  
X-0-X (4-6;4-8);  
X-0-X (4-8;4-6);  
X-0-X (4-8;4-8);  
0-X-X (4-6;4-6);  
0-X-X (4-6;4-8);  
0-X-X (4-8;4-6);  
0-X-X (4-8;4-8);  
X-X-X (4-6;4-6);  
X-X-X (4-6;4-8);

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X-CAT  
O-EC

FIG. 39D

X-X-X (4-8; 4-6);  
X-X-X (4-8; 4-8);

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X-CAT  
O-EC

(LEVEL III)

FIG. 39E

0-0 (4-6; 4-6) |  
0-0 (4-6; 4-8) |  
0-0 (4-8; 4-6) |  
0-0 (4-8; 4-8) |  
X-0 (4-6; 4-6) |  
X-0 (4-6; 4-8) |  
X-0 (4-8; 4-6) |  
X-0 (4-8; 4-8) |  
0-X (4-6; 4-6) |  
0-X (4-6; 4-8) |  
0-X (4-8; 4-6) |  
0-X (4-8; 4-8) |  
0-X (4-6; 4-6) |  
0-X (4-6; 4-8) |  
0-X (4-8; 4-6) |  
0-X (4-8; 4-8) |  
X-0 (4-6; 4-6) |  
X-0 (4-6; 4-8) |  
X-0 (4-8; 4-6) |  
X-0 (4-8; 4-8) |  
0-0 (4-6; 4-6) |  
0-0 (4-6; 4-8) |  
0-0 (4-8; 4-6) |  
0-0 (4-8; 4-8) |  
0-X (4-6; 4-6) |  
0-X (4-6; 4-8) |  
0-X (4-8; 4-6) |  
0-X (4-8; 4-8) |  
X-X (4-6; 4-6) |  
X-X (4-6; 4-8) |  
X-X (4-8; 4-6) |  
X-X (4-8; 4-8) |

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X-CAT  
O-EC

( CONTINUE - LEVEL II )

FIG. 39F

0-0-0 (4-6;4-6)  
0-0-0 (4-6;4-8)  
0-0-0 (4-8;4-6)  
0-0-0 (4-8;4-8)  
X-0-0 (4-6;4-6)  
X-0-0 (4-6;4-8)  
X-0-0 (4-8;4-6)  
X-0-0 (4-8;4-8)  
0-X-0 (4-6;4-6)  
0-X-0 (4-6;4-8)  
0-X-0 (4-8;4-6)  
0-X-0 (4-8;4-8)  
X-X-0 (4-6;4-6)  
X-X-0 (4-6;4-8)  
X-X-0 (4-8;4-6)  
X-X-0 (4-8;4-8)  
0-0-X (4-6;4-6)  
0-0-X (4-6;4-8)  
0-0-X (4-8;4-6)  
0-0-X (4-8;4-8)  
X-0-X (4-6;4-6)  
X-0-X (4-6;4-8)  
X-0-X (4-8;4-6)  
X-0-X (4-8;4-8)  
0-X-X (4-6;4-6)  
0-X-X (4-6;4-8)  
0-X-X (4-8;4-6)  
0-X-X (4-8;4-8)  
X-X-X (4-6;4-6)  
X-X-X (4-6;4-8)  
X-X-X (4-8;4-6)  
X-X-X (4-8;4-8)





X=CAT  
0=EC

(CONTINUE OF LEVEL III)

FIG. 39 I

X-X-0-X (4-8; 4-8; 4-8);

0-0-X-X (4-6; 4-6; 4-6);

0-0-X-X (4-6; 4-6; 4-8);

0-0-X-X (4-6; 4-8; 4-6);

0-0-X-X (4-6; 4-8; 4-8);

0-0-X-X (4-8; 4-6; 4-6);

0-0-X-X (4-8; 4-6; 4-8);

0-0-X-X (4-8; 4-8; 4-6);

X-0-X-X (4-6; 4-6; 4-8);

X-0-X-X (4-6; 4-6; 4-8);

X-0-X-X (4-6; 4-8; 4-6);

X-0-X-X (4-6; 4-8; 4-8);

X-0-X-X (4-8; 4-6; 4-6);

X-0-X-X (4-8; 4-6; 4-8);

X-0-X-X (4-8; 4-8; 4-6);

X-0-X-X (4-8; 4-8; 4-8);

0-X-X-X (4-6; 4-6; 4-6);

0-X-X-X (4-6; 4-6; 4-8);

0-X-X-X (4-6; 4-8; 4-6);

0-X-X-X (4-6; 4-8; 4-8);

0-X-X-X (4-8; 4-6; 4-6);

0-X-X-X (4-8; 4-6; 4-8);

X-X-X-X (4-6; 4-6; 4-6);

X-X-X-X (4-6; 4-6; 4-8);

X-X-X-X (4-6; 4-8; 4-6);

X-X-X-X (4-6; 4-8; 4-8);

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X-CAJ  
0-EC

( CONTINUE LEVEL III )

FIG. 39J

[illegible]

**SUBSTITUTE SHEET (RULE 26)**



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X-CAT  
O-EC

FIG. 39K

X-X-X-X (4-8; 4-6; 4-6)  
X-X-X-X (4-8; 4-6; 4-8)  
X-X-X-X (4-8; 4-8; 4-6)  
X-X-X-X (4-8; 4-8; 4-8)

SUBSTITUTE SHEET (RULE 26)

X-CAT  
O-EC

(LEVEL IV)

FIG. 39L

[illegible]

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X = CAT  
O = EC

( CONTINUE - LEVEL IV )

FIG. 39M

[illegible]

**SUBSTITUTE SHEET (RULE 26)**

X-CAT  
O=EC

(CONTINUE LEVEL IV)

FIG. 39N

[illegible]

**SUBSTITUTE SHEET (RULE 26)**

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X-CAT  
O-EC

( CONTINUE LEVEL IV )

FIG. 390

0-X-X-0-0	(4-6; 4-8; 4-8; 4-6)
0-X-X-0-0	(4-6; 4-8; 4-8; 4-8)
0-X-X-0-0	(4-8; 4-6; 4-6; 4-6)
0-X-X-0-0	(4-8; 4-6; 4-6; 4-8)
0-X-X-0-0	(4-8; 4-6; 4-8; 4-6)
0-X-X-0-0	(4-8; 4-8; 4-8; 4-8)
0-X-X-0-0	(4-6; 4-6; 4-6; 4-6)
0-X-X-0-0	(4-6; 4-6; 4-6; 4-8)
X-X-X-0-0	(4-6; 4-6; 4-8; 4-6)
X-X-X-0-0	(4-6; 4-6; 4-8; 4-8)
X-X-X-0-0	(4-6; 4-6; 4-6; 4-6)
X-X-X-0-0	(4-6; 4-6; 4-6; 4-8)
X-X-X-0-0	(4-6; 4-8; 4-8; 4-6)
X-X-X-0-0	(4-6; 4-8; 4-8; 4-8)
X-X-X-0-0	(4-6; 4-8; 4-6; 4-6)
X-X-X-0-0	(4-6; 4-8; 4-6; 4-8)
X-X-X-0-0	(4-8; 4-6; 4-8; 4-6)
X-X-X-0-0	(4-8; 4-6; 4-8; 4-8)
X-X-X-0-0	(4-8; 4-6; 4-6; 4-6)
X-X-X-0-0	(4-8; 4-6; 4-6; 4-8)
X-X-X-0-0	(4-8; 4-8; 4-8; 4-8)
X-X-X-0-0	(4-8; 4-8; 4-6; 4-6)
X-X-X-0-0	(4-8; 4-8; 4-6; 4-8)
0-0-0-X-X	(4-6; 4-6; 4-8; 4-6)
0-0-0-X-X	(4-6; 4-6; 4-8; 4-8)
0-0-0-X-X	(4-6; 4-6; 4-6; 4-6)
0-0-0-X-X	(4-6; 4-6; 4-6; 4-8)
0-0-0-X-X	(4-6; 4-6; 4-8; 4-6)
0-0-0-X-X	(4-6; 4-8; 4-8; 4-6)
0-0-0-X-X	(4-6; 4-8; 4-8; 4-8)
0-0-0-X-X	(4-6; 4-8; 4-8; 4-8)

**SUBSTITUTE SHEET (RULE 26)**

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X=CAT  
O=EC

(CONTINUE LEVEL IV)

FIG. 39P

[illegible]

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$$\begin{matrix} X = CAT \\ O = EC \end{matrix}$$

(CONTINUE LEVEL IV)

FIG. 39Q

[illegible]

**SUBSTITUTE SHEET (RULE 26)**

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X = CAT  
O = EC

(CONTINUE LEVEL IV)

FIG. 39A

0-0-X-X-X (4-8, 4-8, 4-6, 4-6)  
 0-0-X-X-X (4-8, 4-8, 4-6, 4-8)  
 0-0-X-X-X (4-8, 4-8, 4-8, 4-6)  
 0-0-X-X-X (4-8, 4-8, 4-8, 4-6)  
 X-0-X-X-X (4-6, 4-6, 4-6, 4-6)  
 X-0-X-X-X (4-6, 4-6, 4-6, 4-8)  
 X-0-X-X-X (4-6, 4-6, 4-8, 4-6)  
 X-0-X-X-X (4-6, 4-6, 4-8, 4-8)  
 X-0-X-X-X (4-6, 4-8, 4-6, 4-6)  
 X-0-X-X-X (4-6, 4-8, 4-6, 4-8)  
 X-0-X-X-X (4-6, 4-8, 4-8, 4-6)  
 X-0-X-X-X (4-6, 4-8, 4-8, 4-8)  
 X-0-X-X-X (4-8, 4-6, 4-6, 4-6)  
 X-0-X-X-X (4-8, 4-6, 4-6, 4-8)  
 X-0-X-X-X (4-8, 4-6, 4-8, 4-6)  
 X-0-X-X-X (4-8, 4-6, 4-8, 4-8)  
 X-0-X-X-X (4-8, 4-8, 4-6, 4-6)  
 X-0-X-X-X (4-8, 4-8, 4-6, 4-8)  
 X-0-X-X-X (4-8, 4-8, 4-8, 4-8)  
 X-0-X-X-X (4-8, 4-8, 4-8, 4-6)  
 X-0-X-X-X (4-8, 4-8, 4-8, 4-8)  
 X-0-X-X-X (4-8, 4-8, 4-8, 4-6)  
 X-0-X-X-X (4-8, 4-8, 4-8, 4-8)  
 X-0-X-X-X (4-8, 4-8, 4-8, 4-6)  
 X-0-X-X-X (4-8, 4-8, 4-8, 4-8)  
 X-0-X-X-X (4-8, 4-8, 4-8, 4-6)  
 X-0-X-X-X (4-8, 4-8, 4-8, 4-8)

**SUBSTITUTE SHEET (RULE 26)**







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X-CAT  
0-EC

(CONTINUE LEVEL V)

FIG. 39U

0-X-0-0-X (4-6, 4-6, 4-8, 4-6)  
 0-X-0-0-X (4-6, 4-6, 4-8, 4-8)  
 0-X-0-0-X (4-6, 4-8, 4-6, 4-6)  
 0-X-0-0-X (4-6, 4-8, 4-6, 4-8)  
 0-X-0-0-X (4-6, 4-8, 4-8, 4-6)  
 0-X-0-0-X (4-6, 4-8, 4-8, 4-8)  
 0-X-0-0-X (4-8, 4-6, 4-6, 4-6)  
 0-X-0-0-X (4-8, 4-6, 4-6, 4-8)  
 0-X-0-0-X (4-8, 4-6, 4-8, 4-6)  
 0-X-0-0-X (4-8, 4-6, 4-8, 4-8)  
 0-X-0-0-X (4-8, 4-8, 4-6, 4-6)  
 0-X-0-0-X (4-8, 4-8, 4-6, 4-8)  
 0-X-0-0-X (4-8, 4-8, 4-8, 4-6)  
 0-X-0-0-X (4-8, 4-8, 4-8, 4-8)  
 X-X-0-0-X (4-6, 4-6, 4-6, 4-6)  
 X-X-0-0-X (4-6, 4-6, 4-6, 4-8)  
 X-X-0-0-X (4-6, 4-6, 4-8, 4-6)  
 X-X-0-0-X (4-6, 4-6, 4-8, 4-8)  
 X-X-0-0-X (4-6, 4-8, 4-6, 4-6)  
 X-X-0-0-X (4-6, 4-8, 4-6, 4-8)  
 X-X-0-0-X (4-6, 4-8, 4-6, 4-8)  
 X-X-0-0-X (4-6, 4-8, 4-8, 4-6)  
 X-X-0-0-X (4-6, 4-8, 4-8, 4-8)  
 X-X-0-0-X (4-8, 4-6, 4-6, 4-6)  
 X-X-0-0-X (4-8, 4-6, 4-6, 4-8)  
 X-X-0-0-X (4-8, 4-6, 4-8, 4-6)  
 X-X-0-0-X (4-8, 4-6, 4-8, 4-8)  
 X-X-0-0-X (4-8, 4-8, 4-6, 4-6)  
 X-X-0-0-X (4-8, 4-8, 4-6, 4-8)  
 X-X-0-0-X (4-8, 4-8, 4-8, 4-6)  
 X-X-0-0-X (4-8, 4-8, 4-8, 4-8)  
 0-0-X-0-X (4-6, 4-6, 4-6, 4-6)  
 0-0-X-0-X (4-6, 4-6, 4-6, 4-8)  
 0-0-X-0-X (4-6, 4-6, 4-8, 4-6)  
 0-0-X-0-X (4-6, 4-6, 4-8, 4-8)

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FIG. 40A

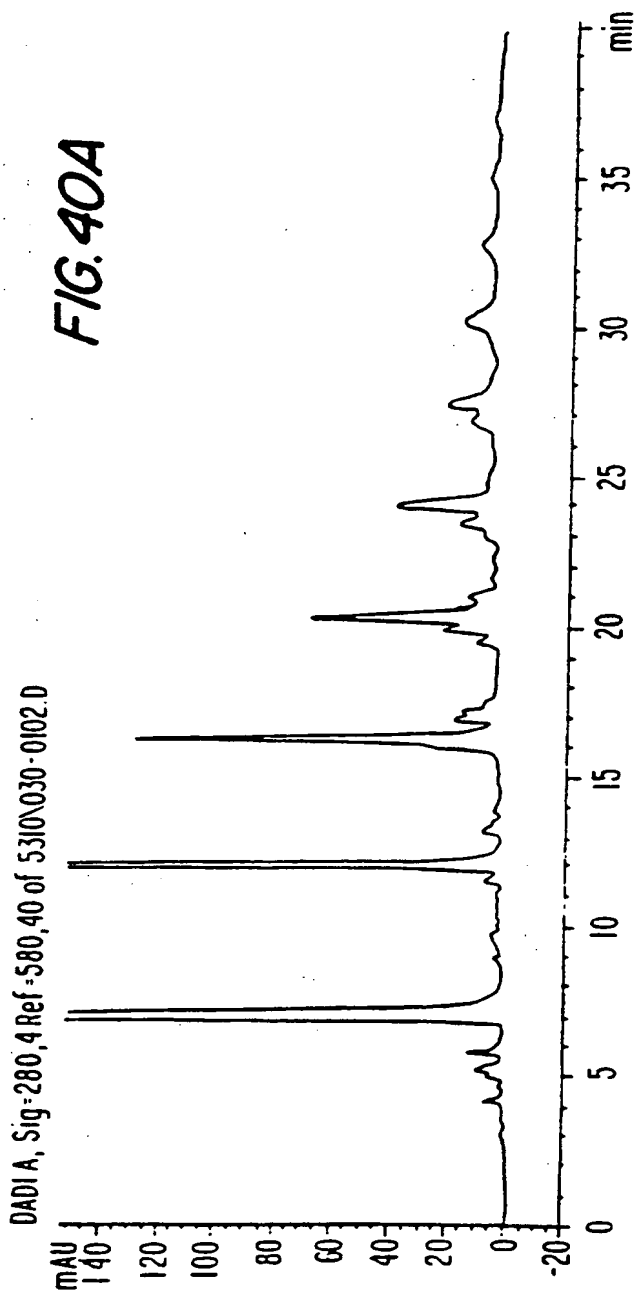
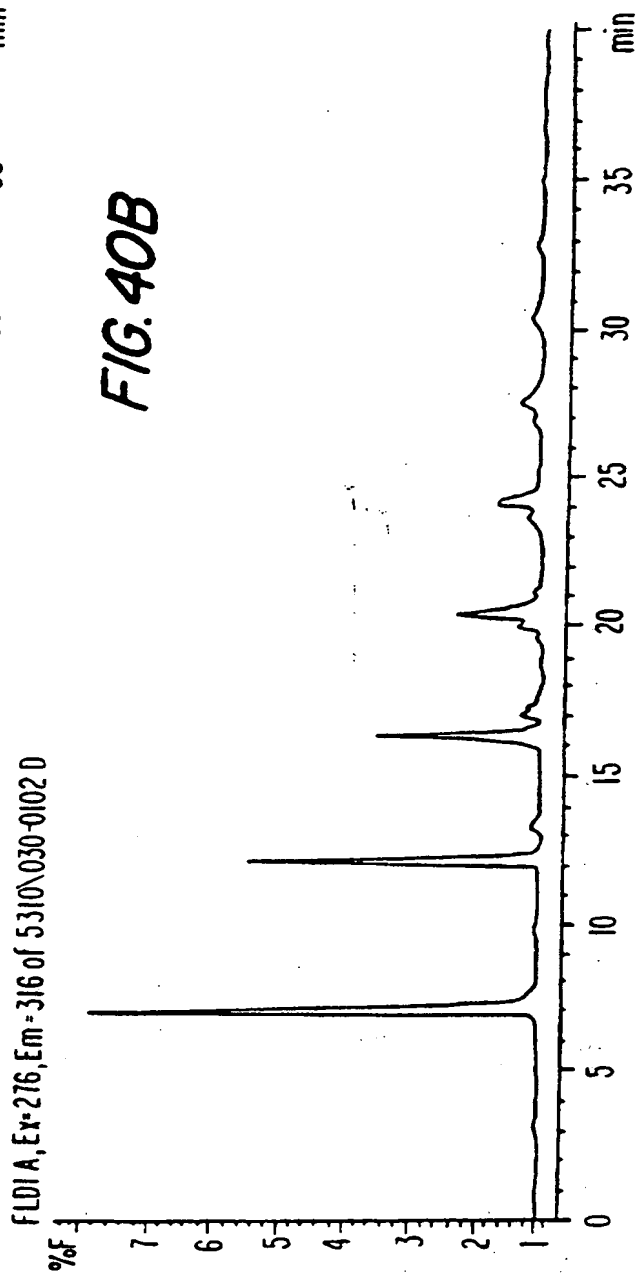
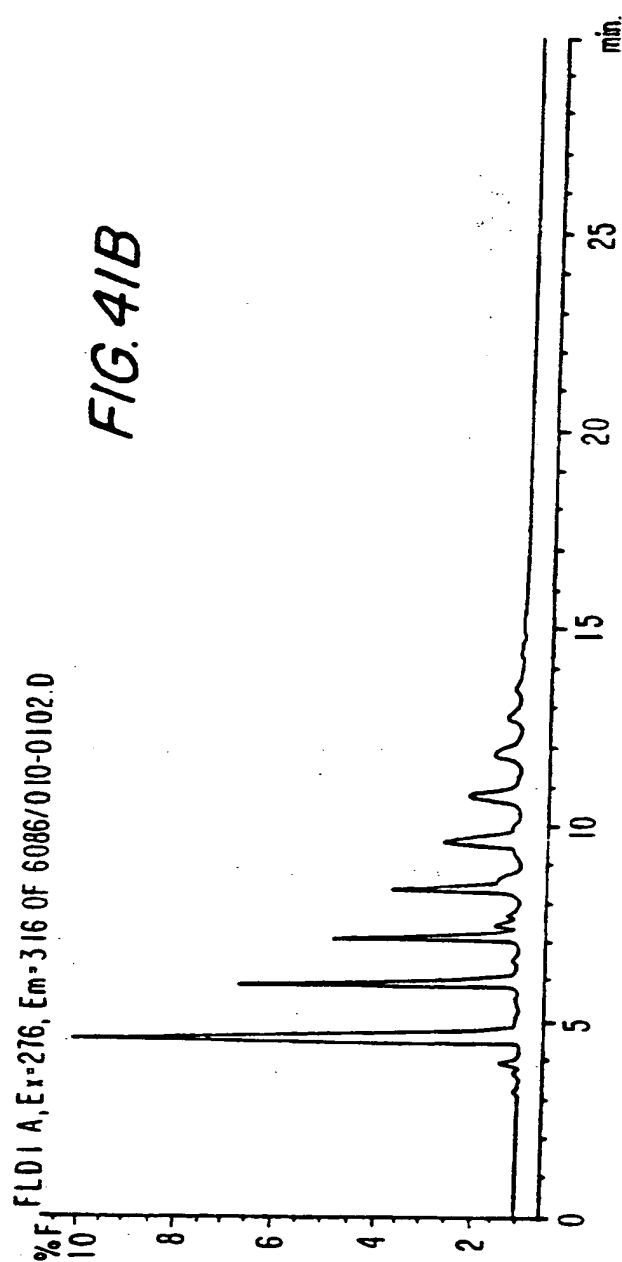
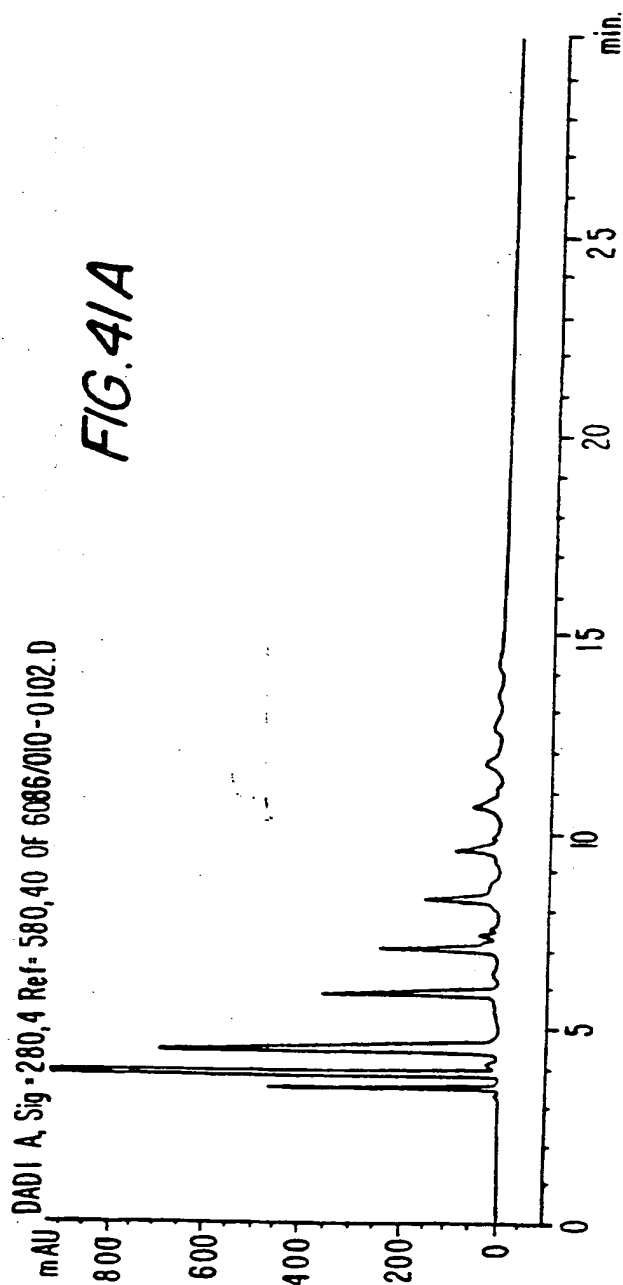


FIG. 40B

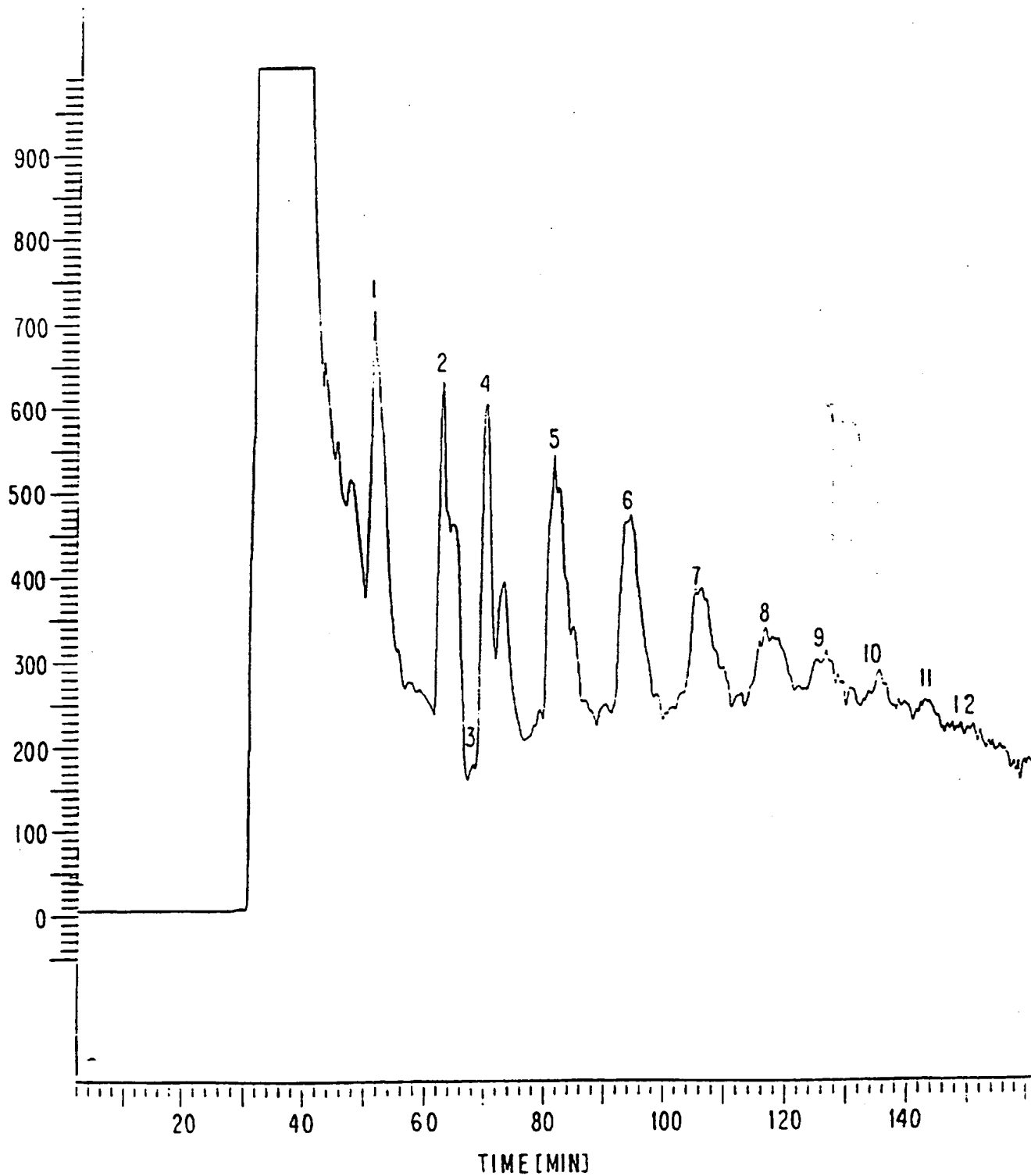


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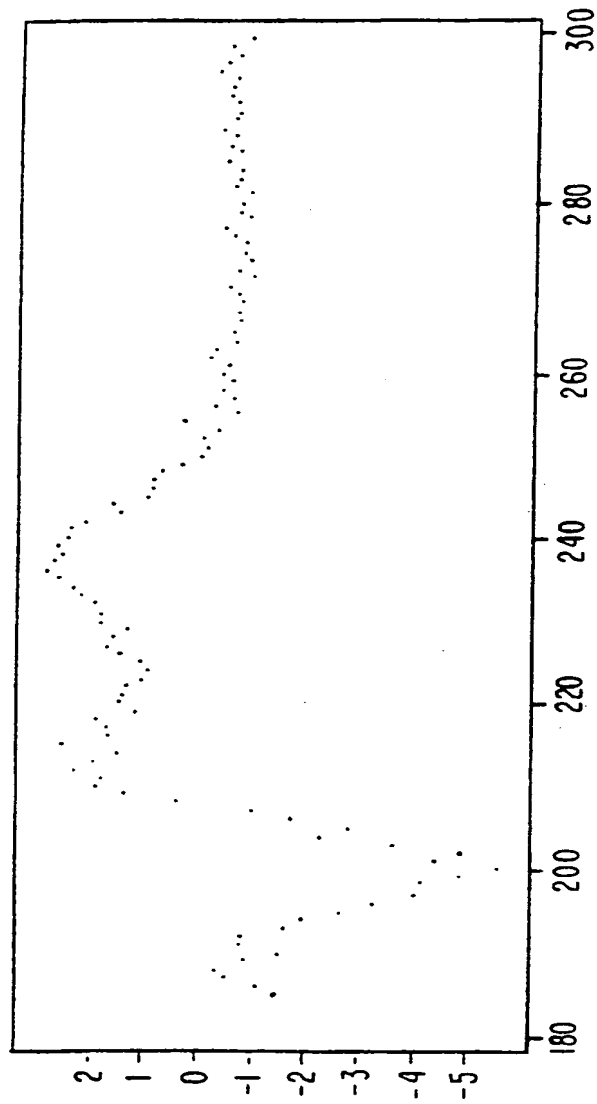
FIG. 42



SUBSTITUTE SHEET (RULE 26)

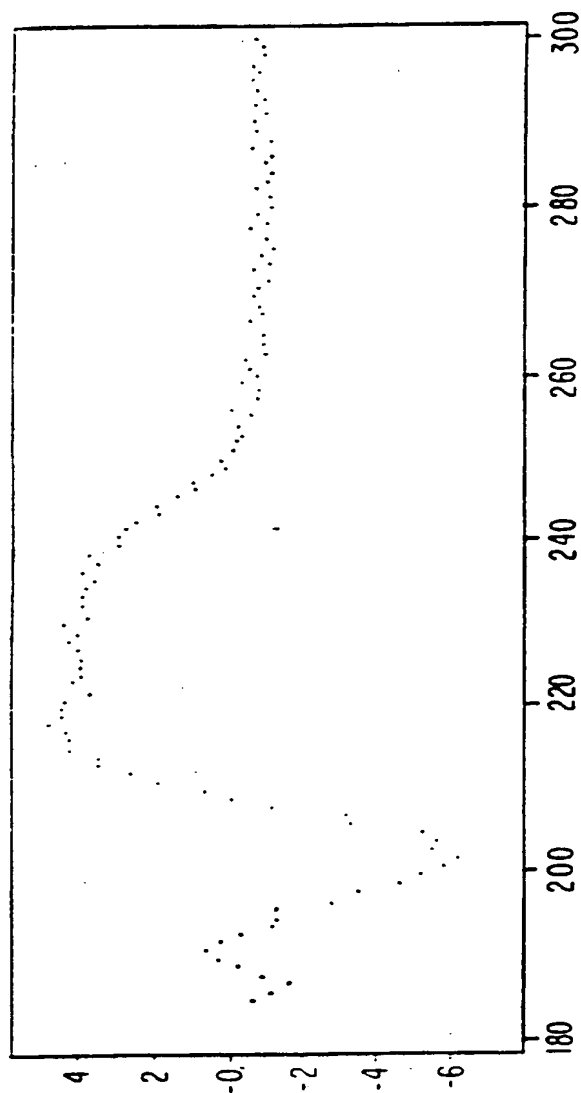
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FIG. 43A



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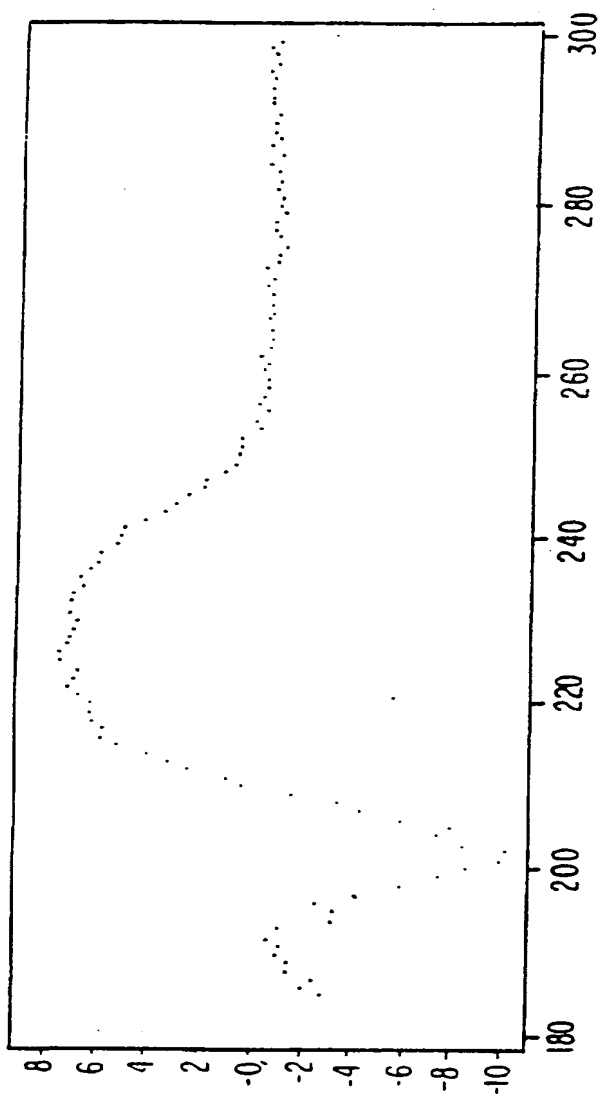
FIG. 43B



SUBSTITUTE SHEET (RULE 26)

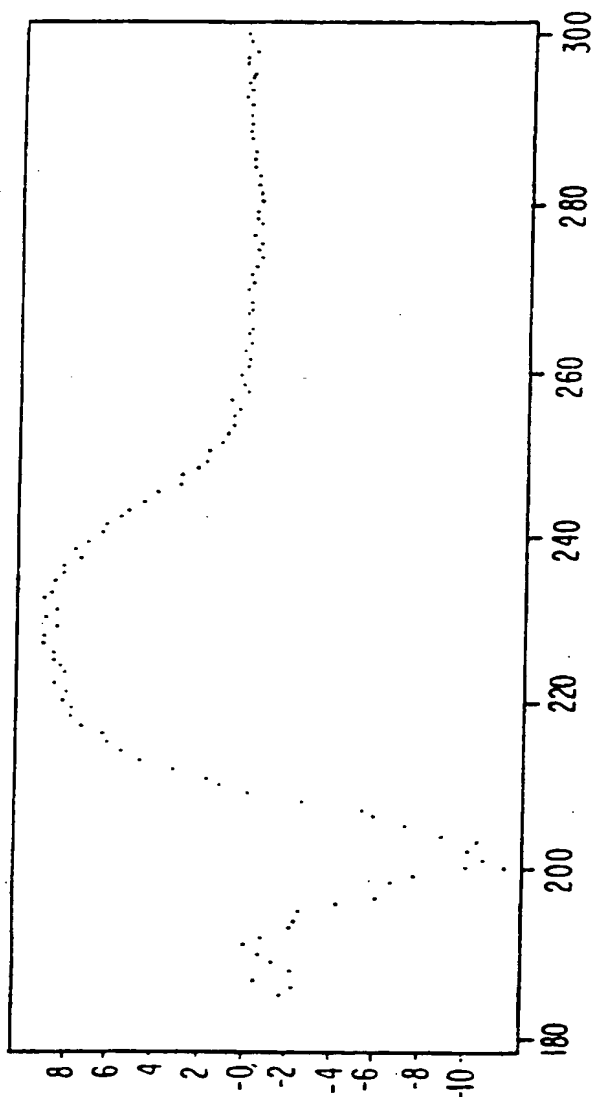
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FIG. 43C



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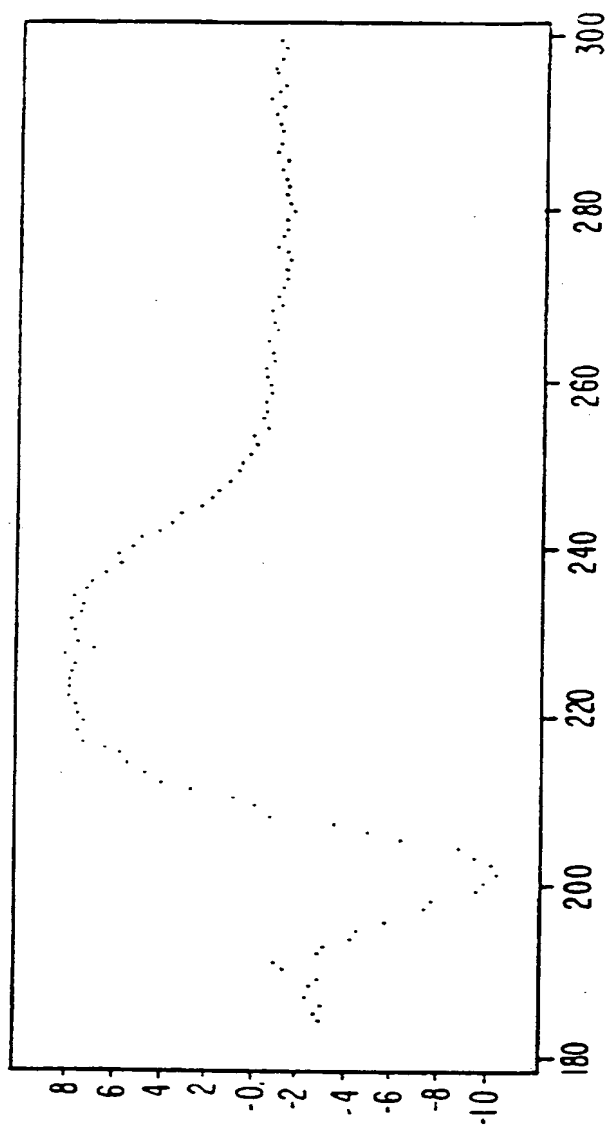
FIG. 43D



SUBSTITUTE SHEET (RULE 26)

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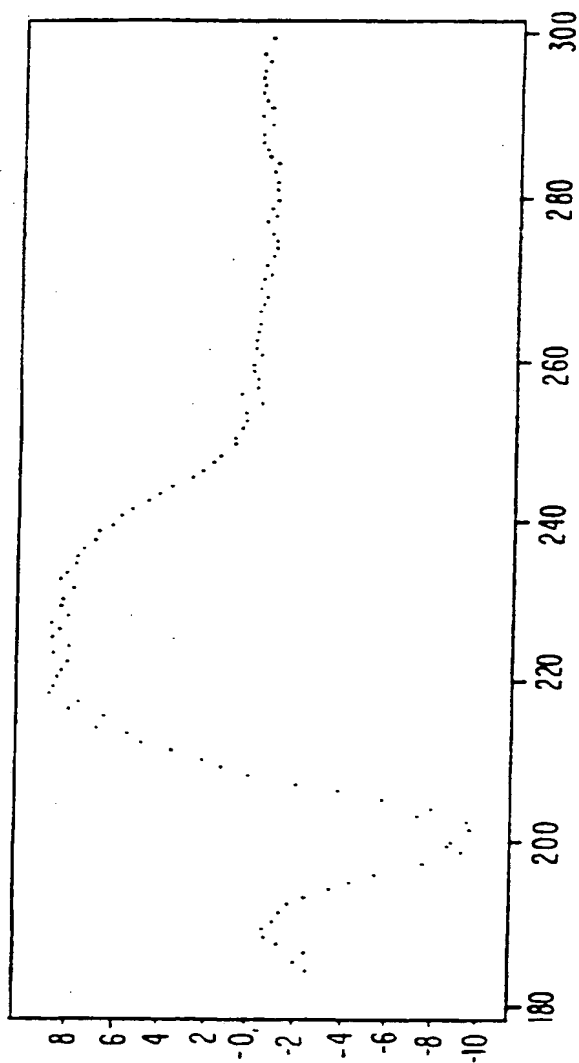
FIG. 43E





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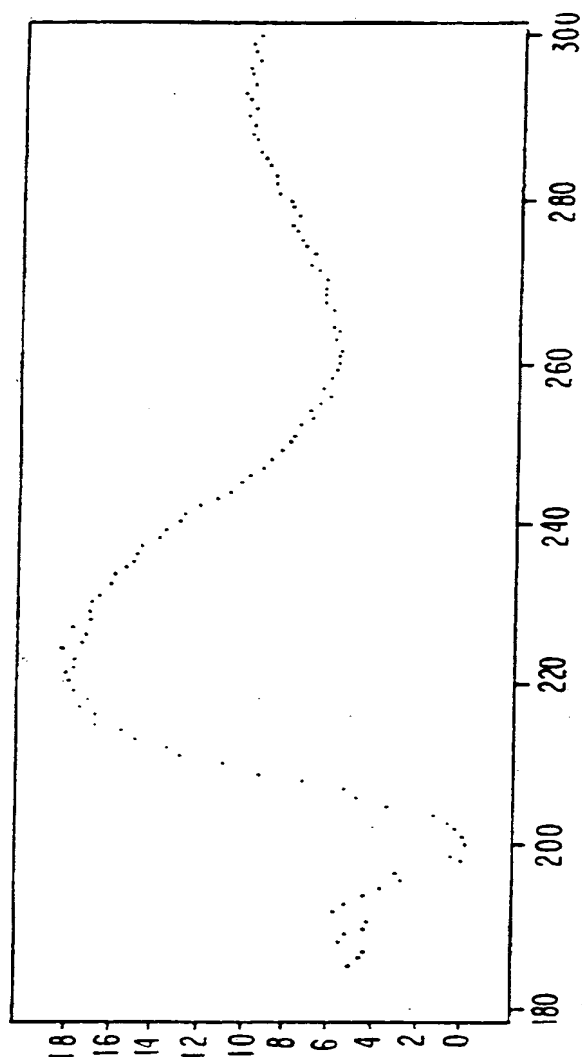
FIG. 43F



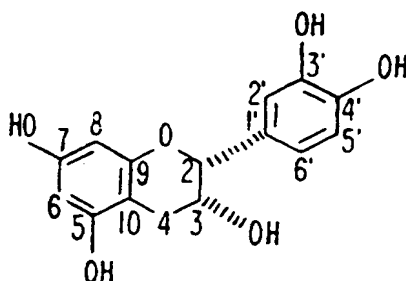
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FIG. 43G



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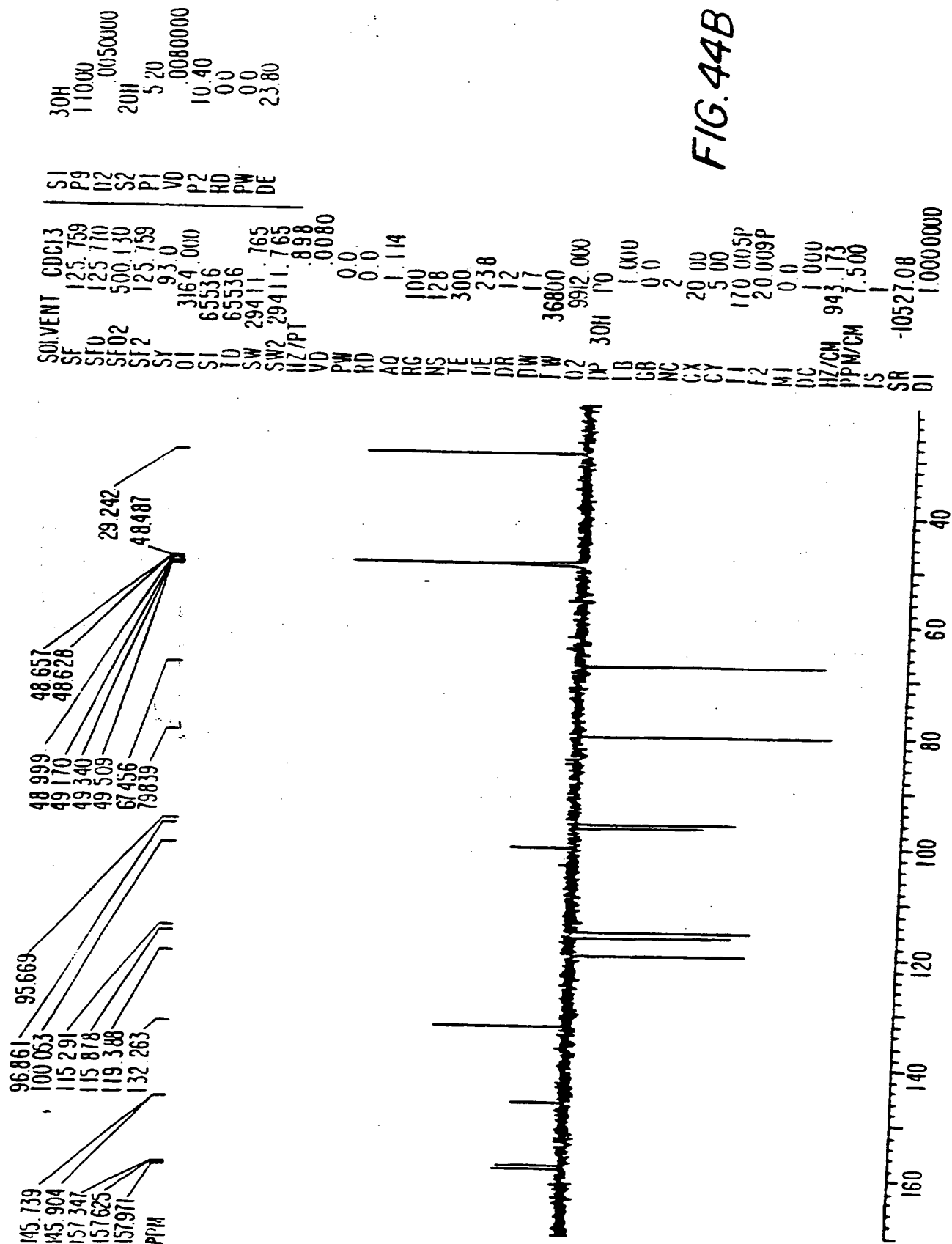


EPI CATECHIN			
<sup>1</sup> H	CHEMICAL SHIFT (ppm)	<sup>13</sup> C	CHEMICAL SHIFT (ppm)
2	4.81	2	79.84
3	4.16	3	67.46
4 <sub>A</sub> } 4 <sub>B</sub> }	{ 2.73 2.85 }	4	29.24
		6	95.87
6	5.94	8	96.36
8	5.91	2'	115.29
5' } 6' }	{ 6.75 6.79 }	5' } 6' }	{ 115.88 119.39 }
2'	6.97		

FIG. 44A

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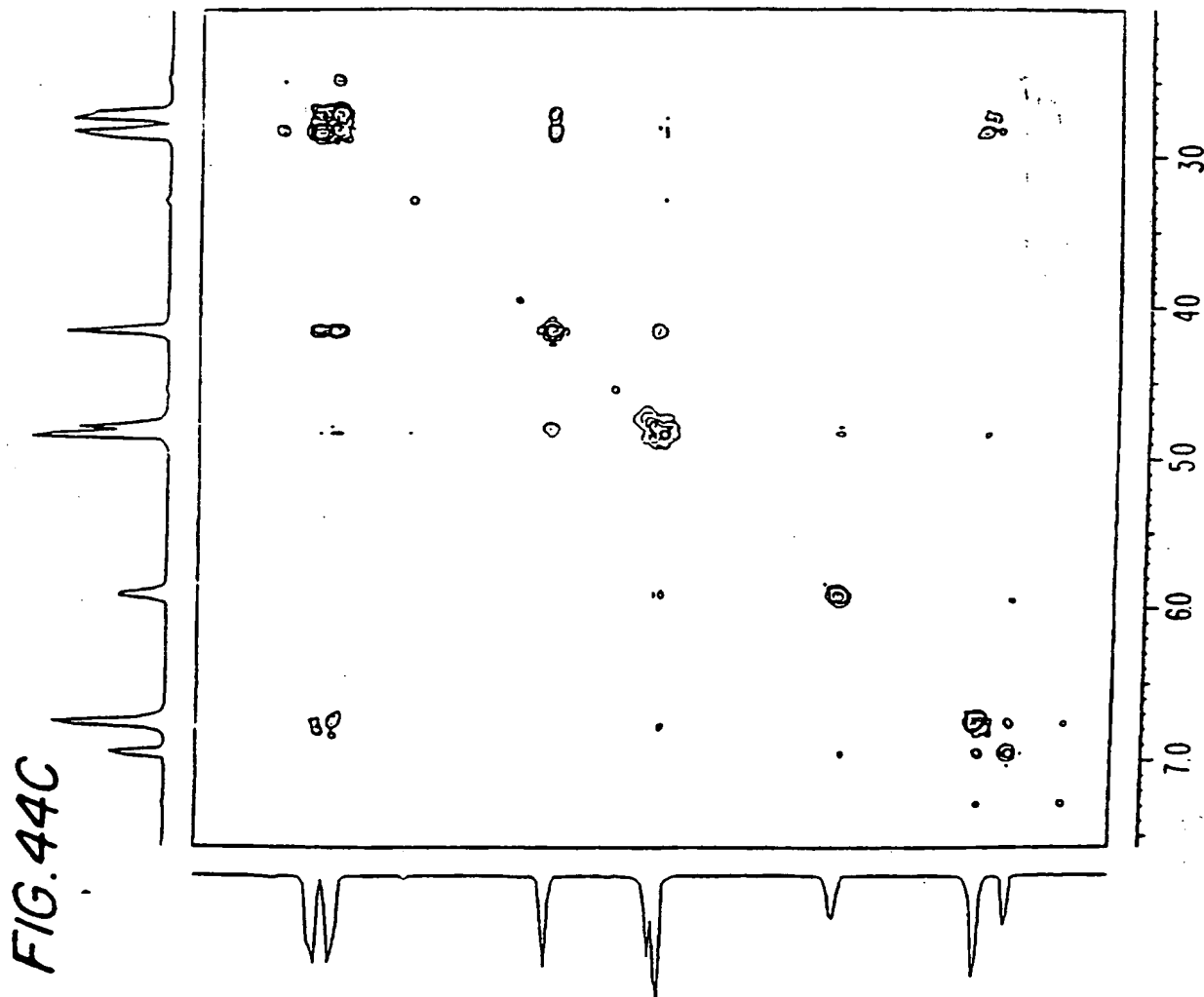
FIG. 44B



SUBSTITUTE SHEET (RULE 26)

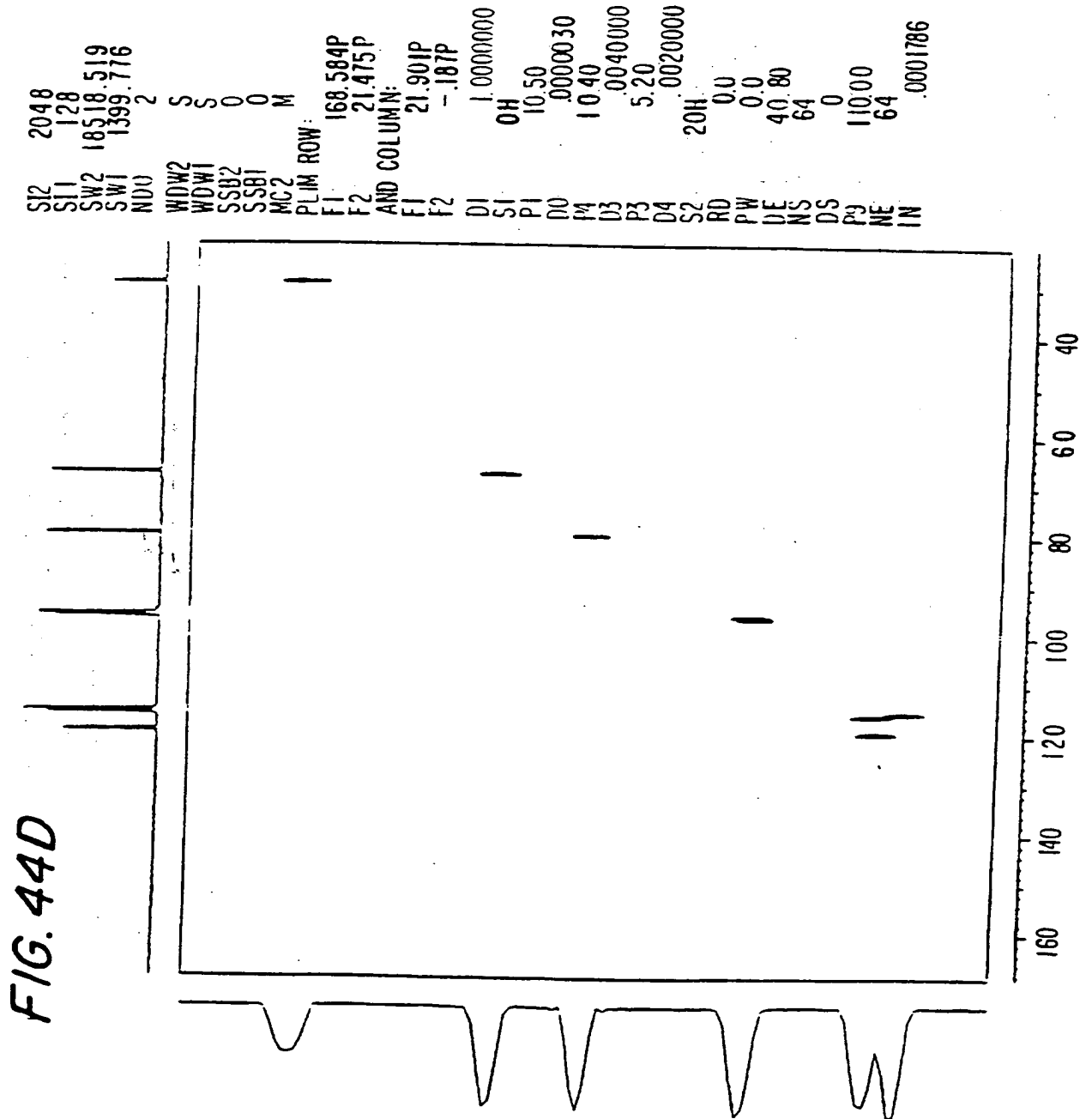
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SI2 512  
 SI1 256  
 SW2 2793.296  
 SW1 1396.648  
 NDO 1  
 WDW2 S  
 WDW1 S  
 SSB2 0  
 SSB1 0  
 MC2 M  
 PLIM ROW:  
 F1 7.573P  
 F2 2.010P  
 AND COLUMN:  
 F1 7.573P  
 F2 2.010P  
 DI 1.0000000  
 PI 10.50  
 DO .0000030  
 P2 5.20  
 RD 0.0  
 PW 0.0  
 DE 256.70  
 NS 4  
 DS 0  
 NE 128  
 IN .0003580



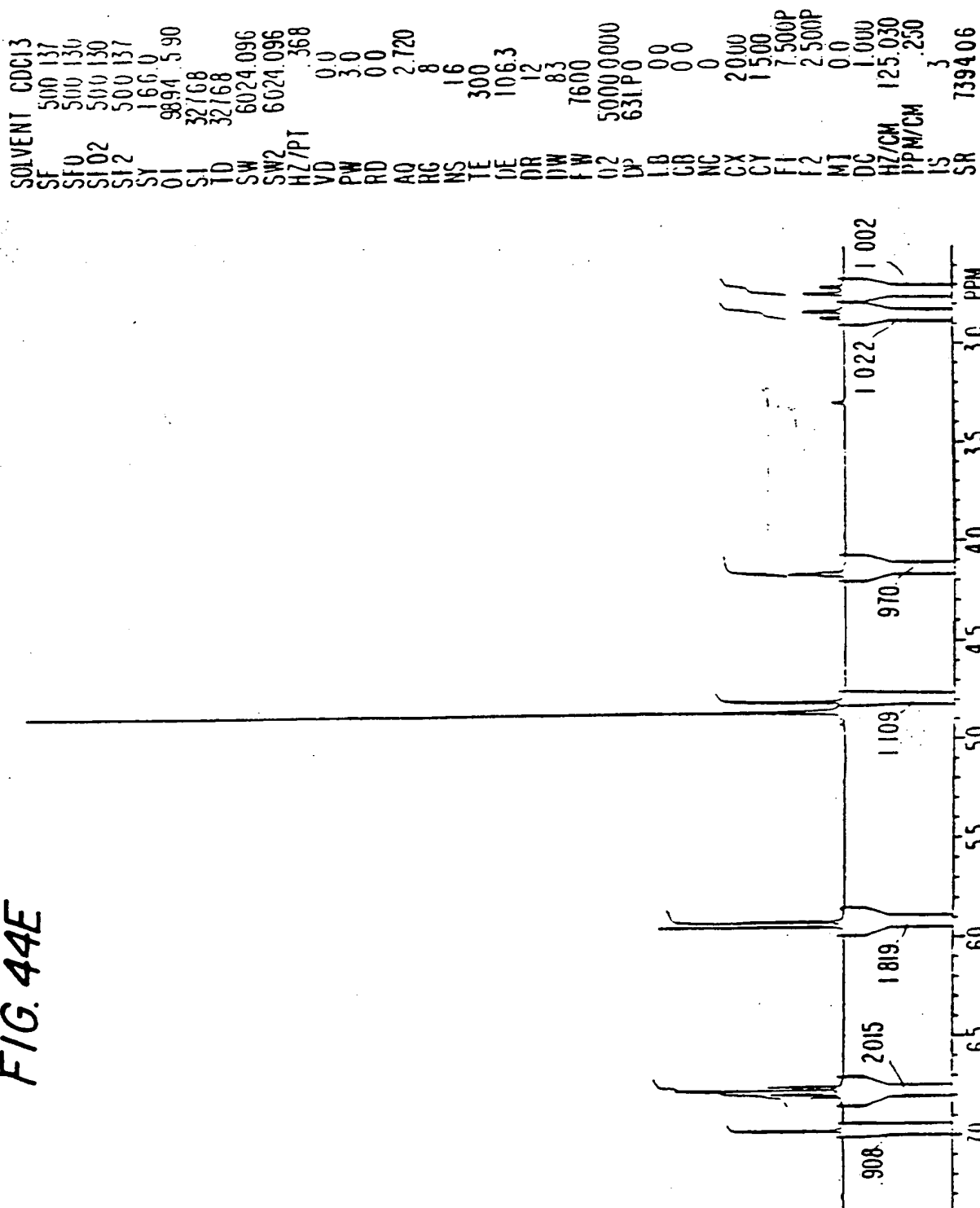
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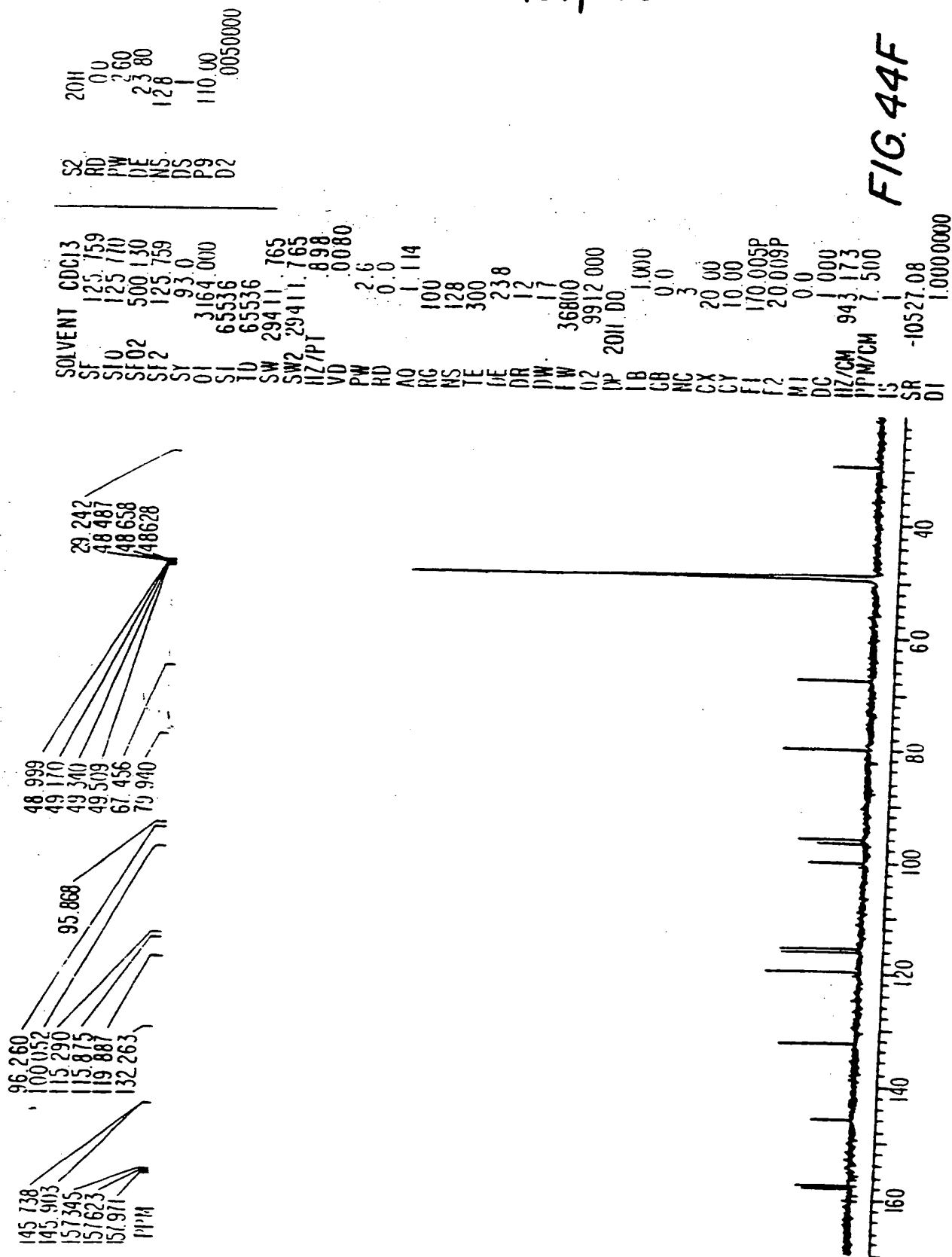
FIG. 44E



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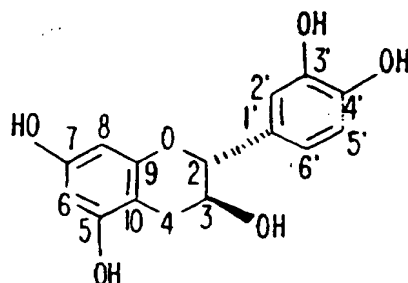
FIG. 44F



**SUBSTITUTE SHEET (RULE 26)**



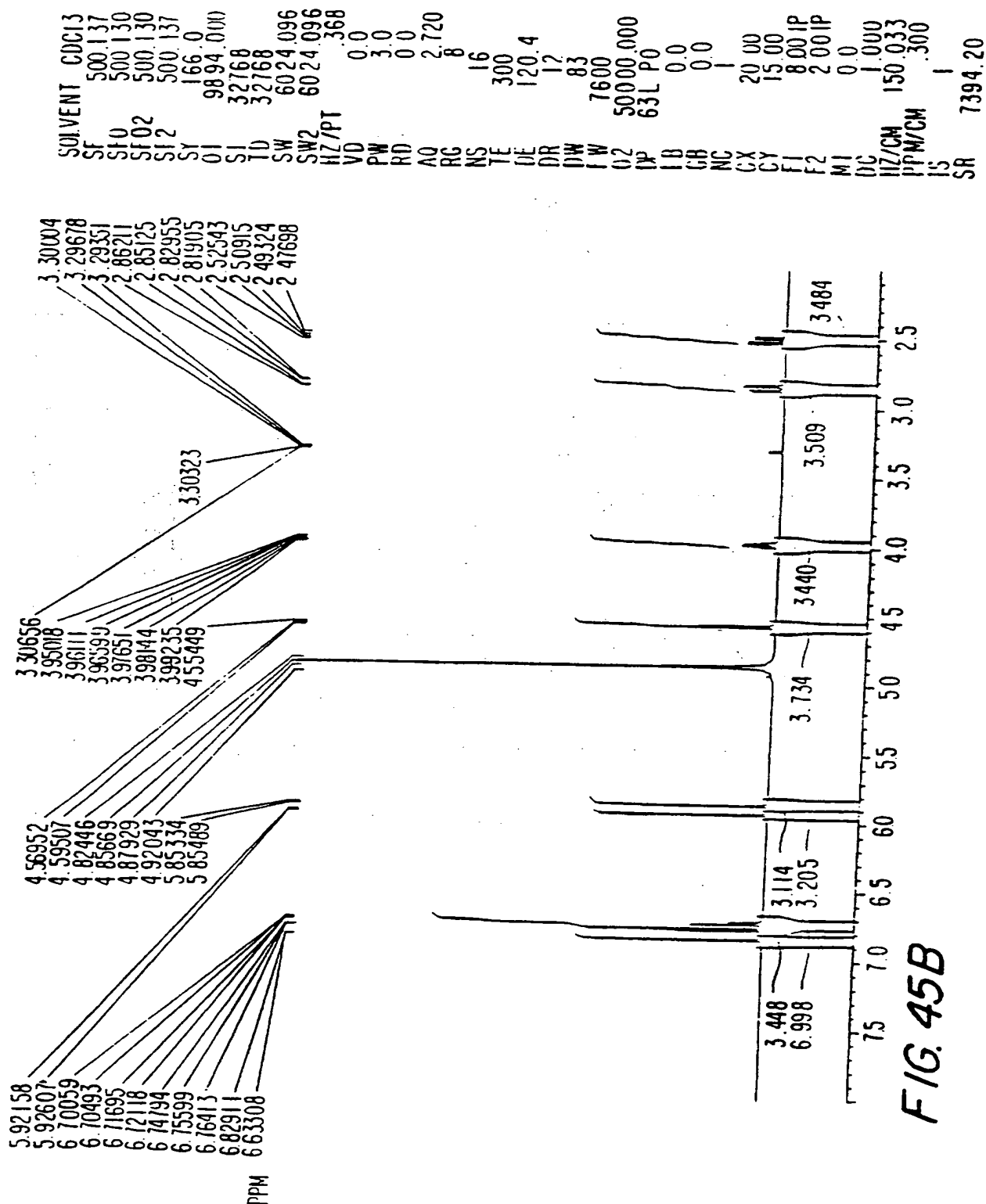
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CATECHIN			
$^1\text{H}$	CHEMICAL SHIFT (ppm)	$^{13}\text{C}$	CHEMICAL SHIFT (ppm)
2	4.56	2	79.84
3	3.97	3	67.46
$4\alpha$ }	{ 2.50 2.84	4	29.24
$4\beta$ }		6	95.87
6	5.85	8	96.36
8	5.92	2'	115.29
2'	6.83	$6'$ } $5'$ }	{ 116.08 120.08
$5'$ }	{ 6.76 6.71		
$6'$ }			

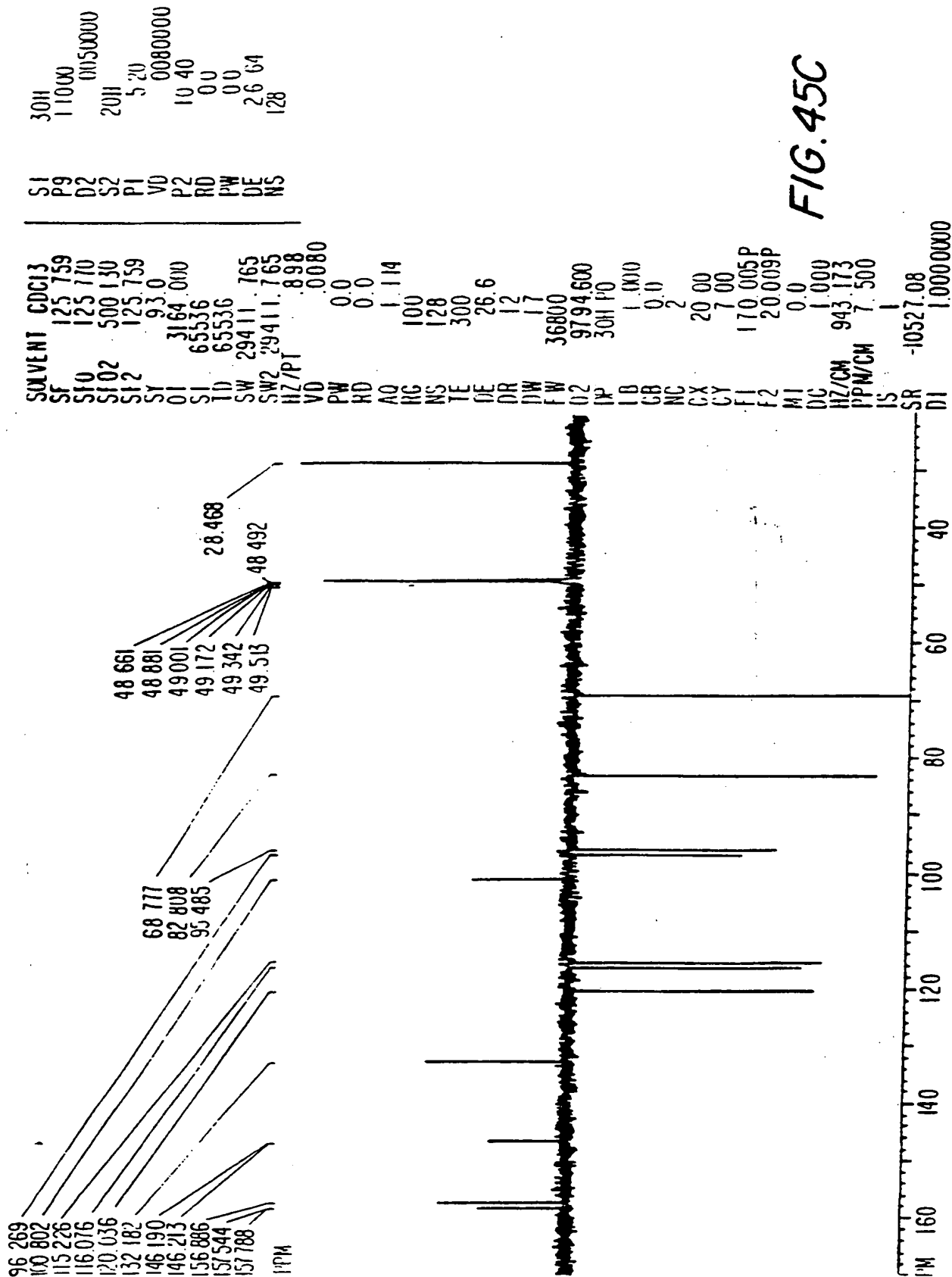
FIG.45A

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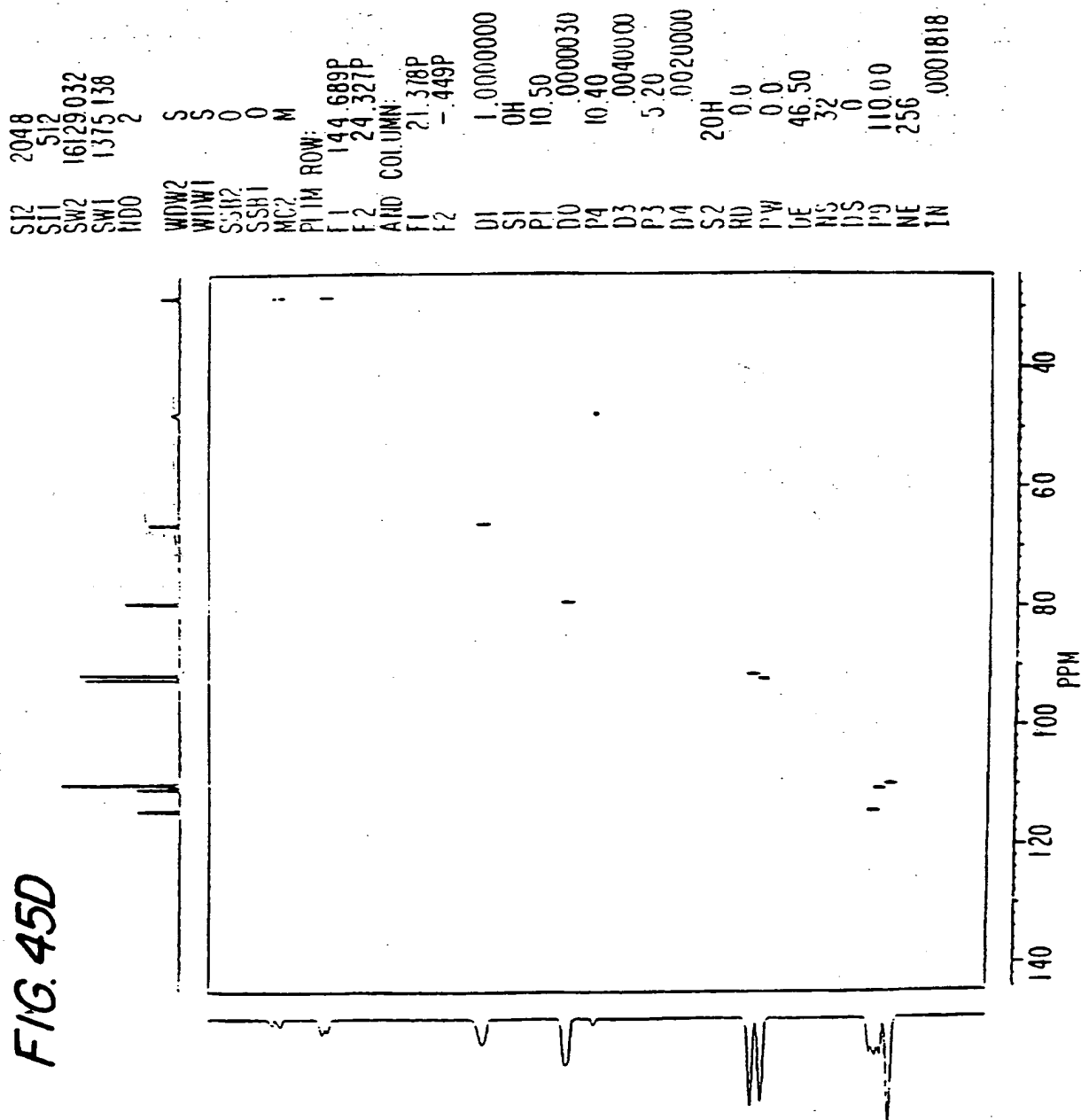
FIG. 45C



SUBSTITUTE SHEET (RULE 26)

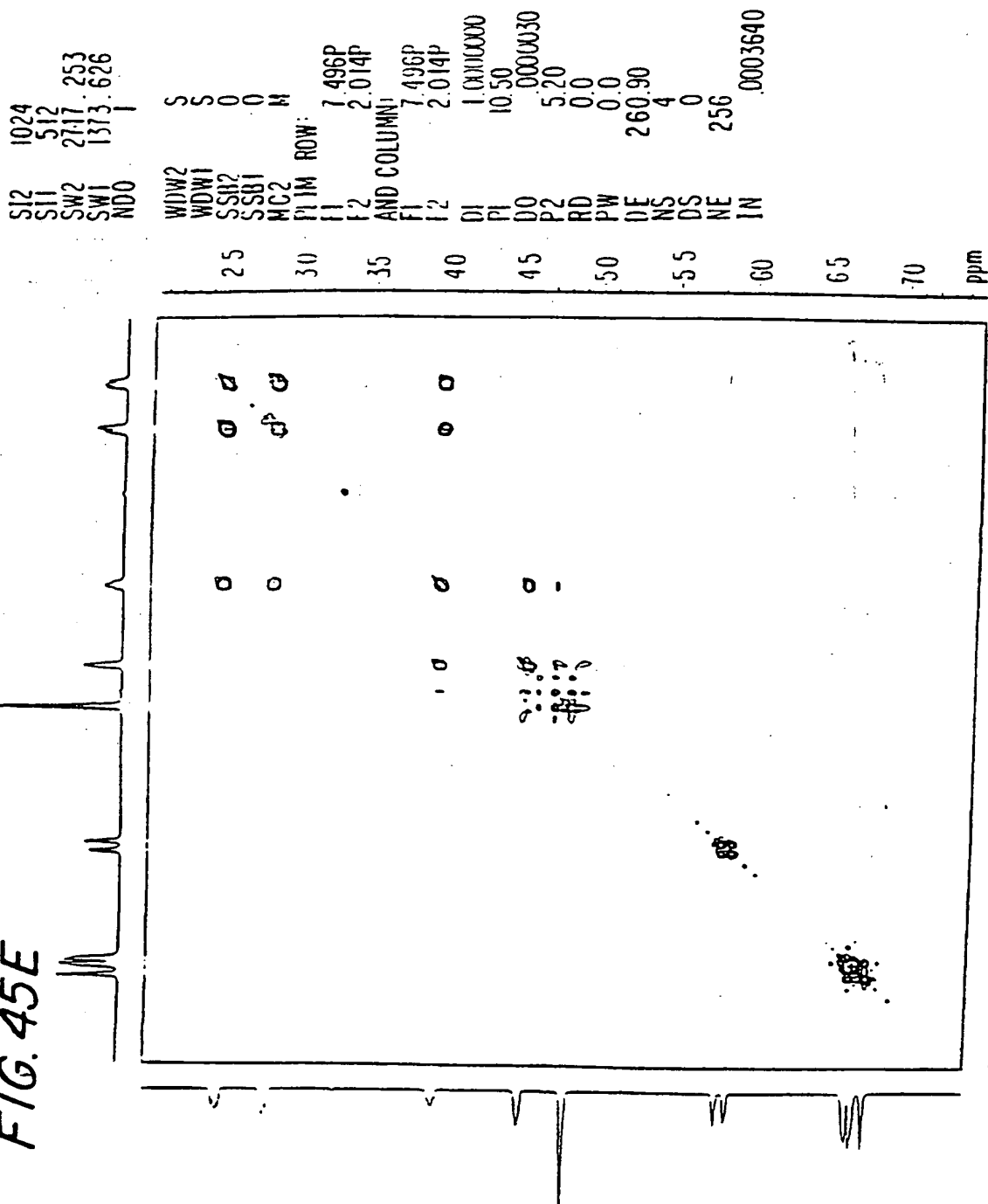
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FIG. 45D



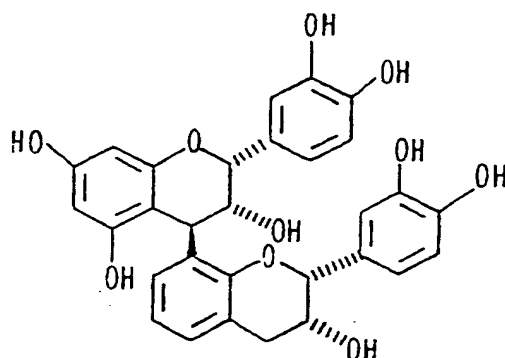
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FIG. 45E



SUBSTITUTE SHEET (RULE 26)

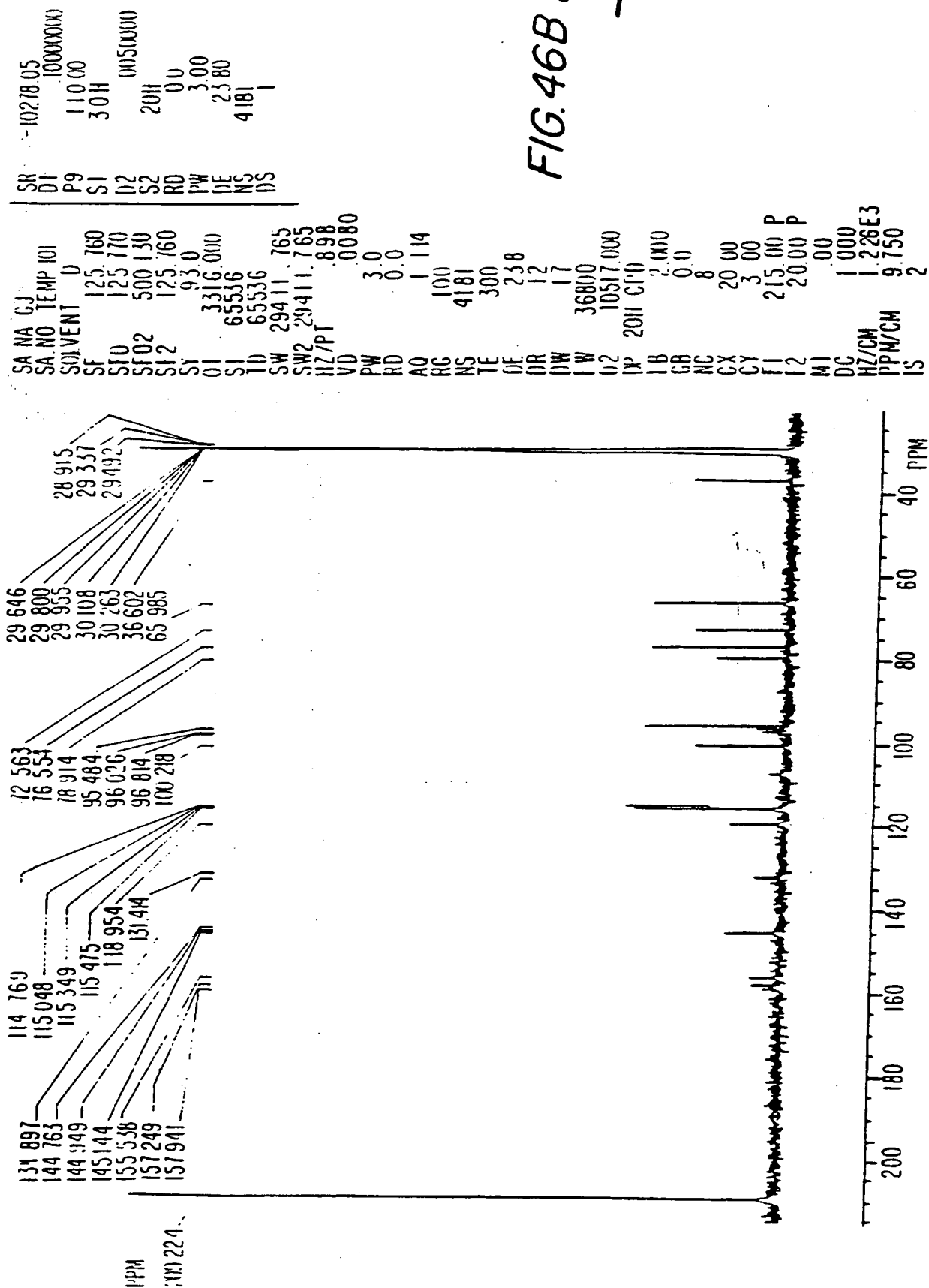
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B2 DIMER			
<sup>1</sup> H	CHEMICAL SHIFT (ppm)	<sup>13</sup> C	CHEMICAL SHIFT (ppm)
B4	2.69 2.83	B4 T4	28.92 36.60
T4	4.63	B3	65.99
B3	4.29	T3	72.56
T3	3.85	T2	76.55
T2	4.99	B2	78.91
B2	4.92	T6 OR 8	95.48
B6	5.92	B6	96.03
T6 OR 8	5.91	T6 OR 8	96.81
T6 OR 8	5.98		100.22
B2'	7.12	B2'	114.77
T2'	6.92	T2'	115.05
T5	6.68	T5'	115.35
B5	6.70	B5'	115.48
T6'	6.87	T6'	118.95
B6'	6.58	B6'	
		T1'	131.41 131.90

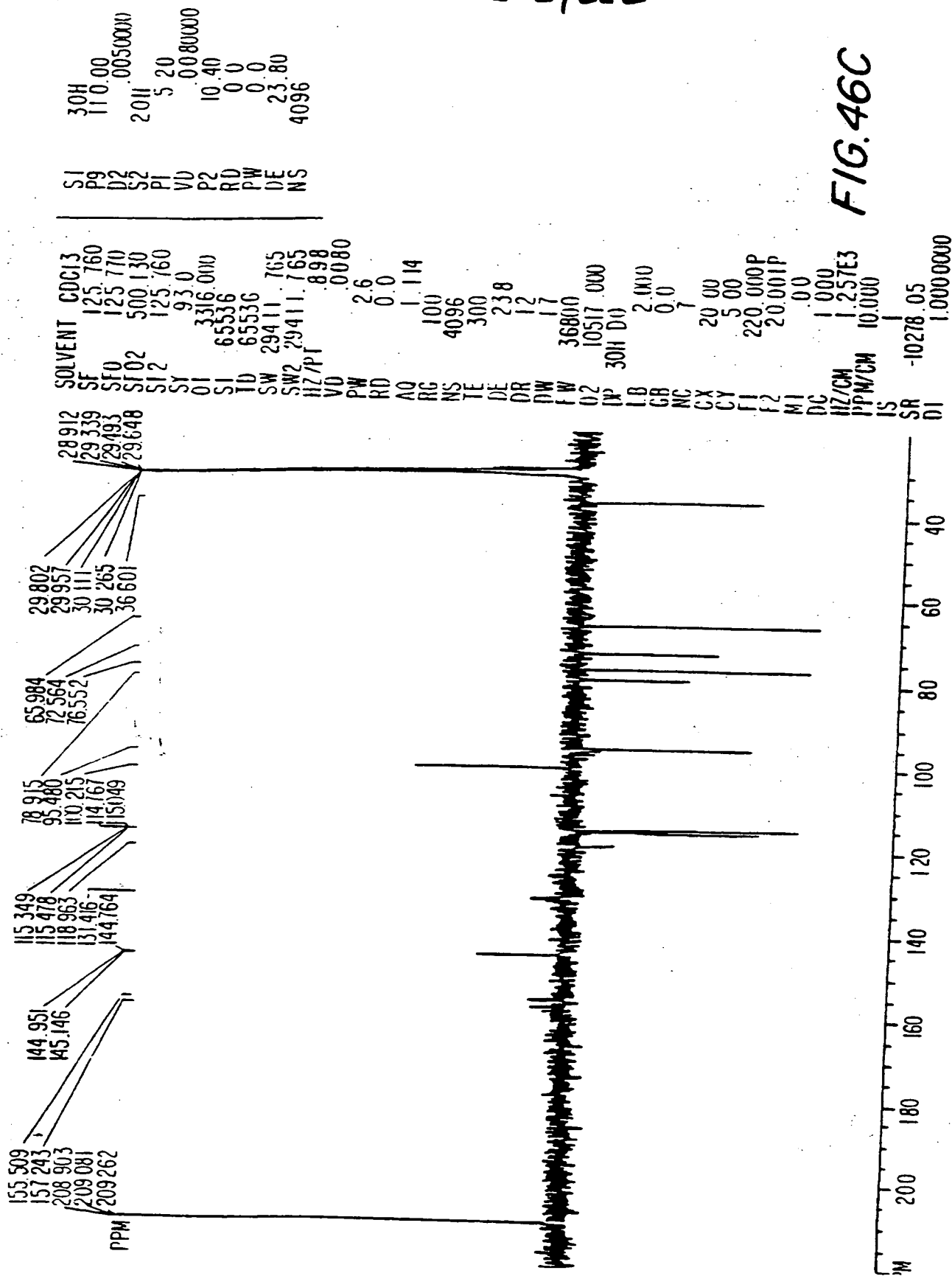
FIG. 46A

FIG. 46B 201/222



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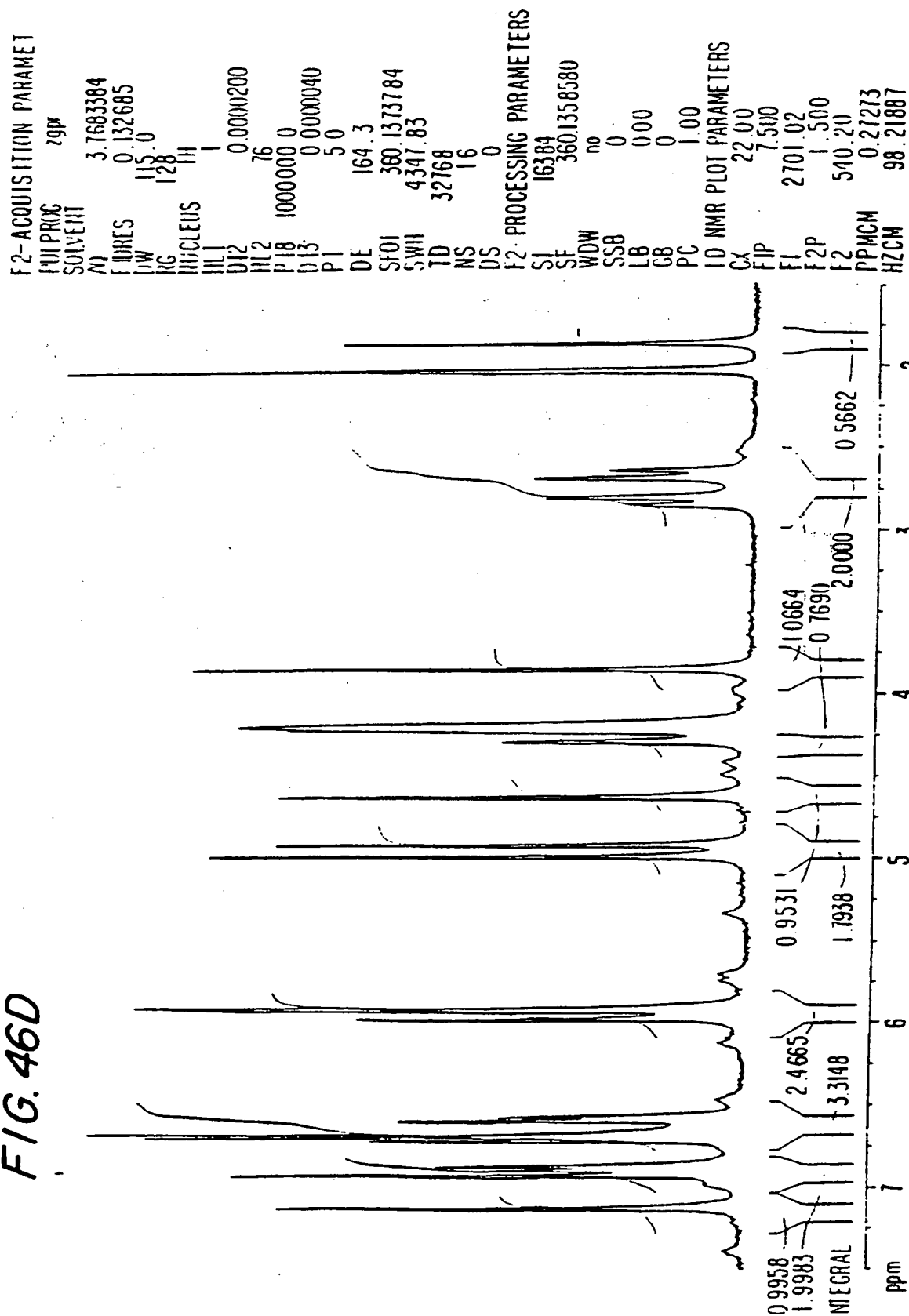
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FIG. 46D

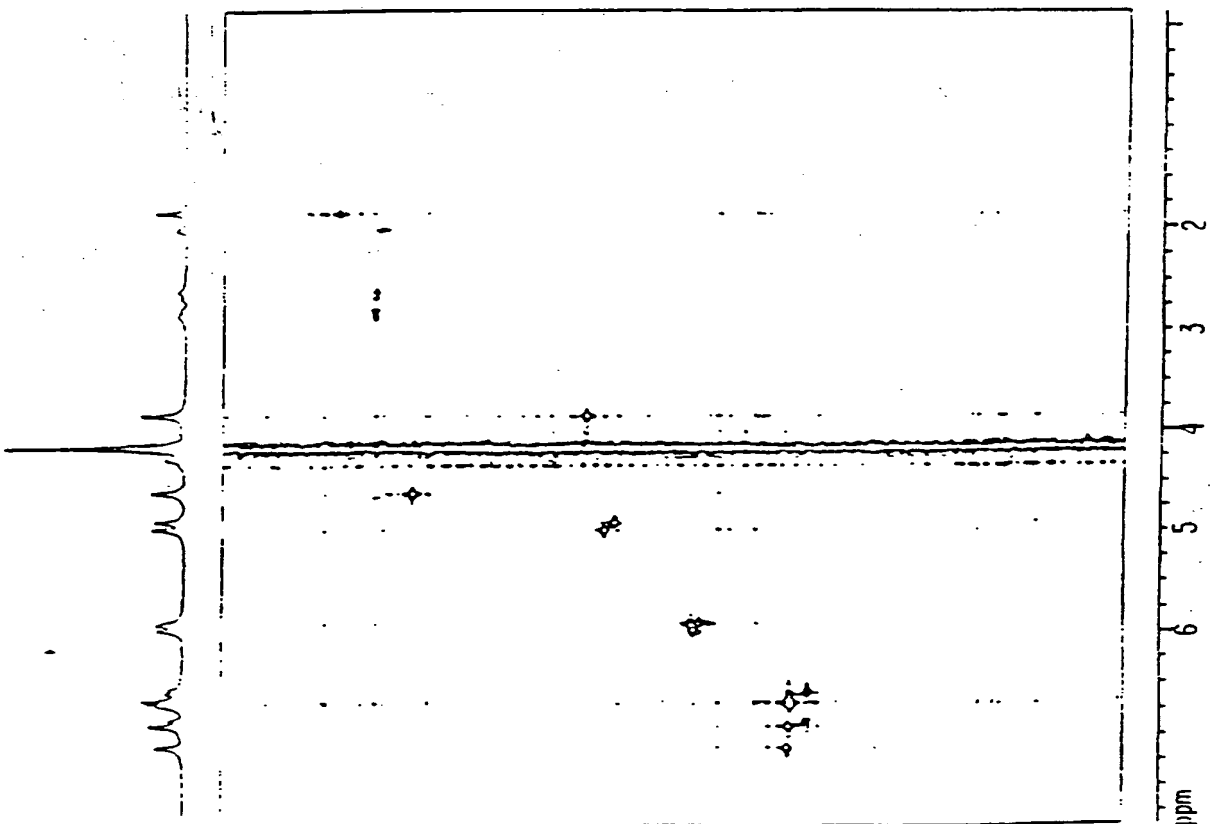


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F1-PROCESSING PARAMETERS		2D NMR PLOT PARAMETERS	
inv4	dioxane	SI	0.00
solvent	0.3543240 sec	MC	0.00
WDW	1.411217 Hz	SF	90.5543832 MHz
RG	173.0 usec	WDW	Q5INE
NUC1	256	SSB	0.00
PI	7.5 usec	LB	0.00
C1S12	1.45.0000000	GB	0.00
IN1	1.0000000 sec	CX2	12.29 cm
D1	0.0034483 sec	CX1	12.29 cm
D2	13.5 usec	F2H0	7.887 ppm
P3	90.5643220 MHz	F2L0	2840.39 Hz
SF02	0.0000030 sec	F2PHI	-0.138 ppm
D0	15.0 usec	F2H1	49.18 Hz
P2	0.0000040 sec	F1P0	182.085 ppm
D13	17.00 dH	F1L0	16488.51 Hz
DL	247.1 usec	F1PHI	-1.932 ppm
SF01	360.132552 MHz	F1H1	-174.94 Hz
SWH	2890.17 Hz	F2PNCM	0.65209 ppm/cm
TD	2048	F2H1CM	235.16463 Hz/cm
P31	65.0 usec	F1P1CM	14.9287 ppm/cm
100 NS	16	F1H1CM	1355.8503 Hz/cm
F1-ACQUISITION PARAMETERS		12-PROCESSING PARAMETERS	
inv4	0.0000300 sec	SI	0.00
solvent	0.3543240 sec	MC	0.00
WDW	1.411217 Hz	SF	90.5543832 MHz
RG	173.0 usec	WDW	Q5INE
NUC1	256	SSB	0.00
PI	7.5 usec	LB	0.00
C1S12	1.45.0000000	GB	0.00
IN1	1.0000000 sec	PC	1.40
D1	0.0034483 sec		
D2	13.5 usec		
P3	90.5643220 MHz		
SF02	0.0000030 sec		
D0	15.0 usec		
P2	0.0000040 sec		
D13	17.00 dH		
DL	247.1 usec		
SF01	360.132552 MHz		
SWH	2890.17 Hz		
TD	2048		
P31	65.0 usec		
100 NS	16		

FIG. 46E



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FIG. 46F

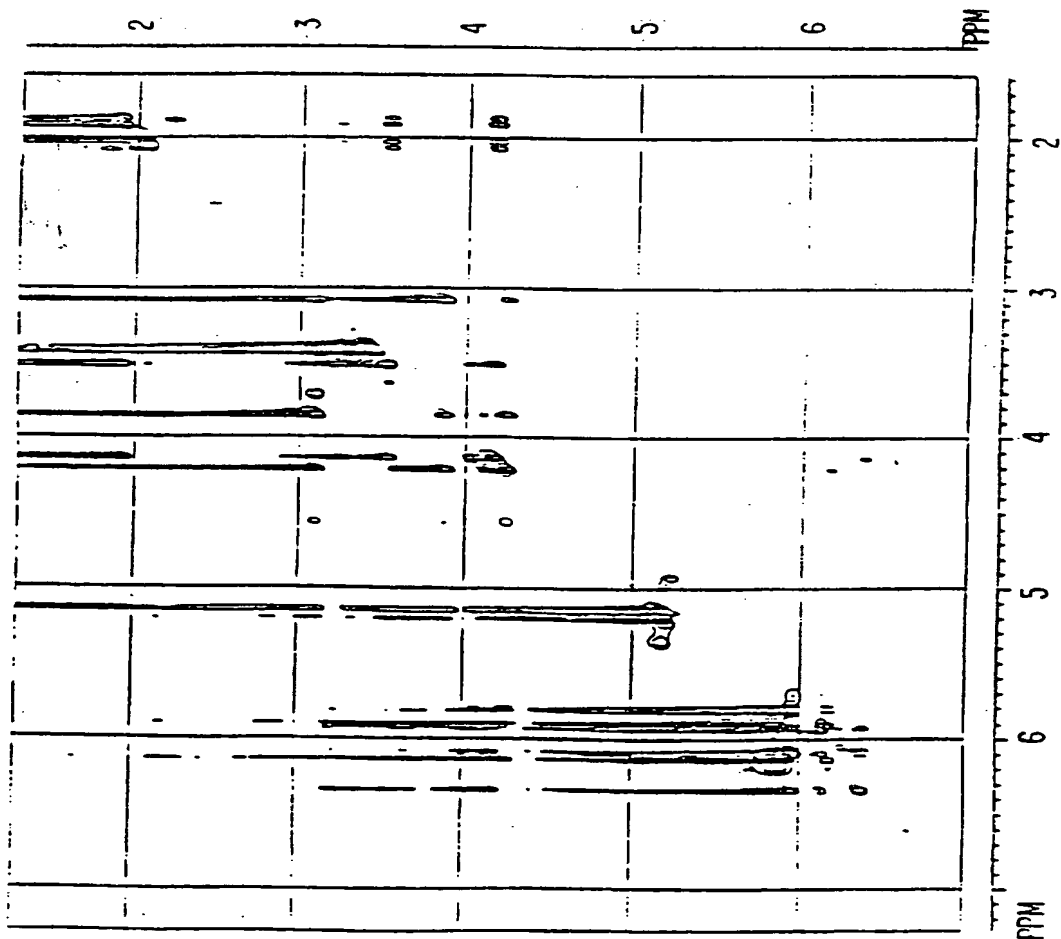


SUBSTITUTE SHEET (RULE 26)

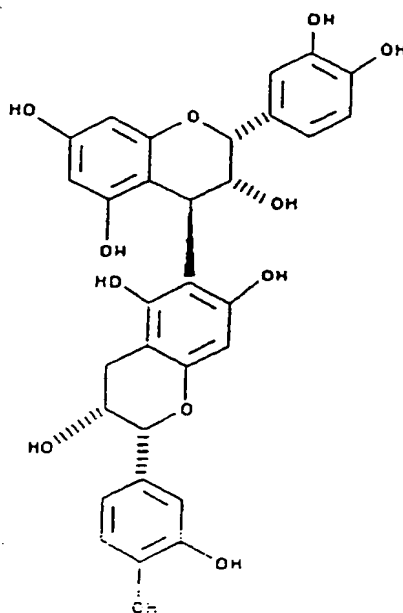
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PULPROG	8.025	ppm
SOLVENT		
NO	0.3543240	sec
TDRES	1.411217	Hz
TDW	173.0	u sec
RG	1.78	Hz
NUCLEUS	1H	
P6	52.0	u sec
H11	1	dB
D11	0.0300000	sec
D12	0.0000200	sec
H12	76	dB
P18	1000000.0	u sec
D13	0.0000040	sec
P1	75	u sec
D0	0.0000030	sec
H13	17	dB
P17	25000	u sec
P7	1040	u sec
L1	56	u sec
P5	34.7	u sec
D1	247.1	u sec
SFOI	360.13744	MHz
SWH	2890.17	Hz
TD	2048	
NS	8	
DS	4	
IRU	0.0001730	sec
FI-ACQUISITION PARAMETERS		
ND10	2	
TD	128	
SFOI	360.1373	MHz
FIRES	22.579477	Hz
SW		
F2-PROCESSING PARAMETERS		
SI	1024	
SF	360.13677	MHz
WDW	SINE	
SSB	4	
LB	0.00	Hz
GB	0	
PC	140	
FI-PROCESSING PARAMETERS		
SI	1024	
MC2	TPP1	
SF	360.1360418	MHz
WDW	SINE	
SSB	4	
LB	0.00	Hz
GB	0	
2D NMR PLOT PARAMETERS		
CX2	1500	cm
CX1	1500	cm
F2110	2622.72	Hz
F210	7.283	ppm
F2PHI	1.577	ppm
F2H1	567.99	Hz
F1P10	6.990	ppm
F110	2517.31	Hz
F1PHI	1.331	ppm
F1H1	479.51	Hz
F211MCM	0.38036	ppm/cm
F211ZCM	136.98227	Hz/cm
F111MCM	0.37723	ppm/cm
F111ZCM	135.85324	Hz/cm

FIG. 46G



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B5 DIMER			
<sup>1</sup> H	CHEMICAL SHIFT (ppm)	<sup>13</sup> C	CHEMICAL SHIFT (ppm)
B4	2.585 7.745	B4 T4	29.04 37.03
T3	3.99	B3	66.49
B3	4.13	T3	71.73
T4	4.54	T2	76.69
B2	4.77	B2	78.98
T2	4.90	B6 + 8	95.49
T6+	6.02		96.11
T8	6.055	T6 + 8	96.32
B8	6.04		100.18
T6'	6.64	T2' + 5'	115.01
T5'	6.74	B2' + 5'	115.38
B5'	6.75	B6	118.90
B6'	6.78	T6	118.98
T2'	6.95	B1'	131.62

FIG. 46 H

SUBSTITUTE SHEET (RULE 26)

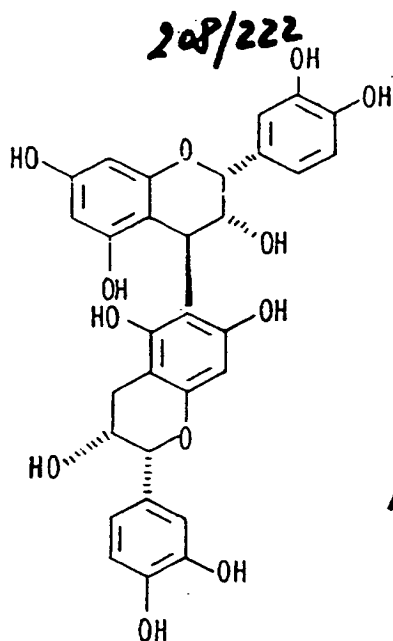
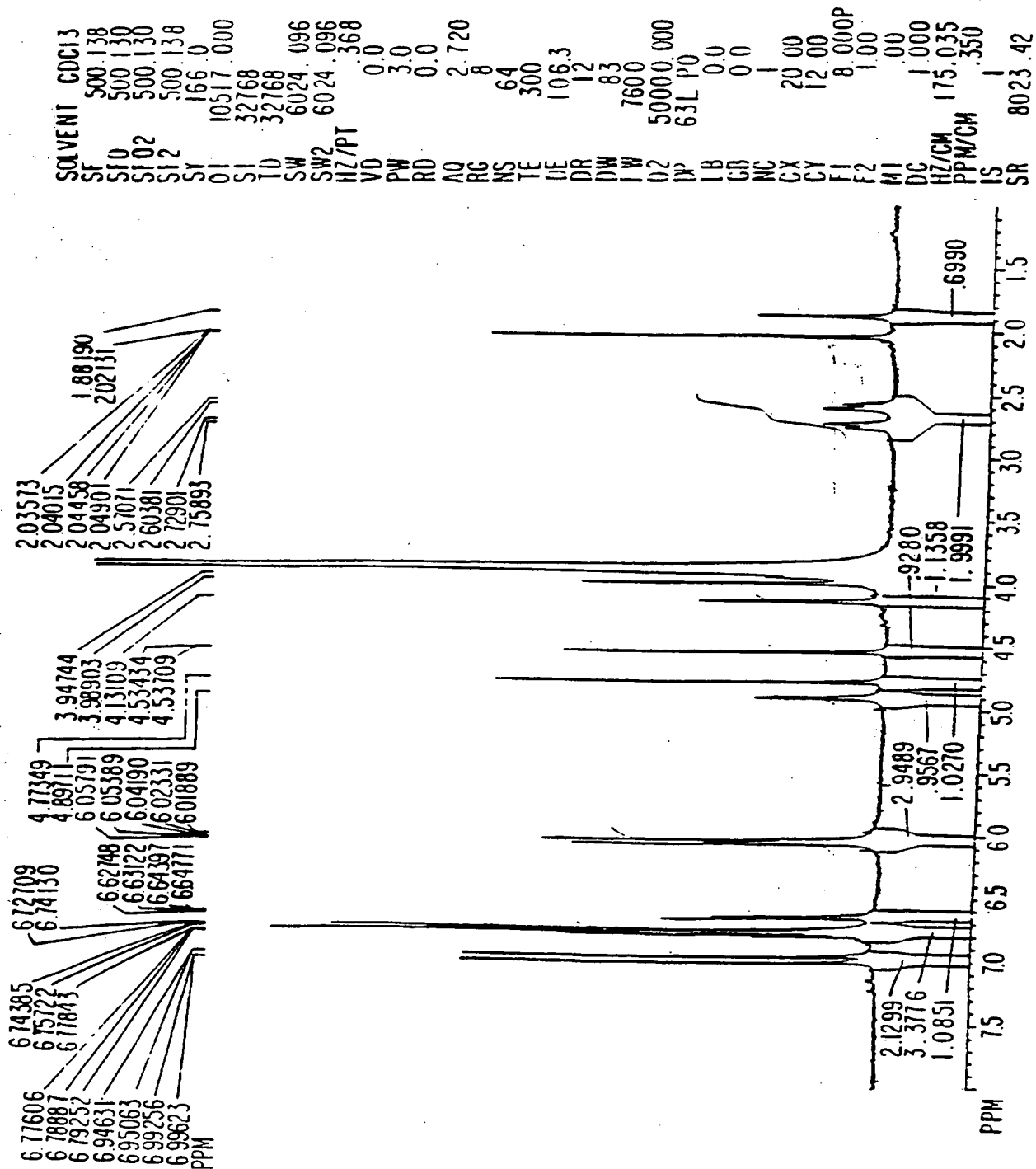


FIG. 47A

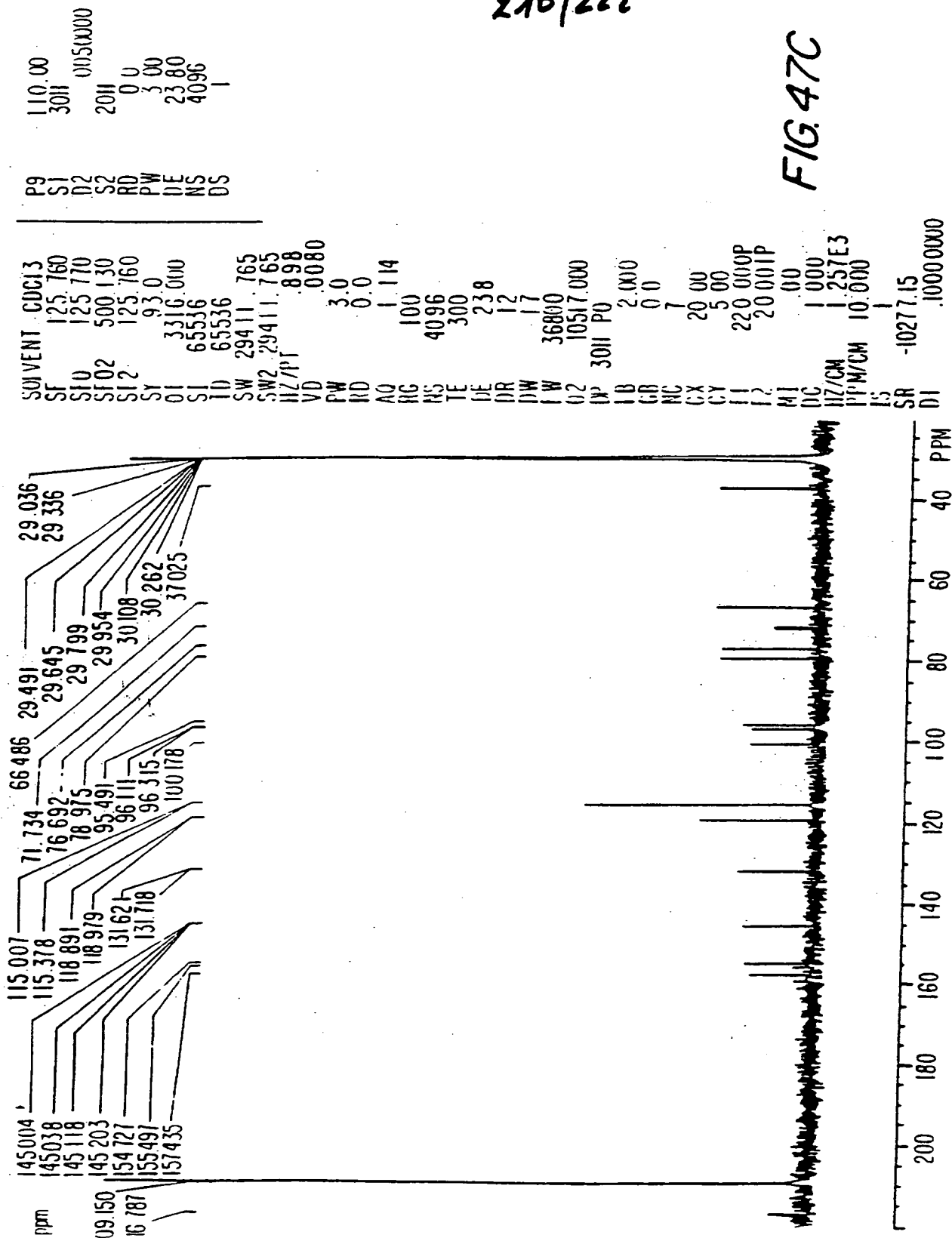
B5 DIMER			
<sup>1</sup> H	CHEMICAL SHIFT (ppm)	<sup>13</sup> C	CHEMICAL SHIFT (ppm)
B4	2.585 7.745	B4 T4	29.04 37.03
T3	3.99	B3	66.49
B3	4.13	T3	71.73
T4	4.54	T2	76.69
B2	4.77	B2	78.98
T2	4.90	B6+8	95.49
T6+	6.02		96.11
T8	6.055	T6+8	96.32
B8	6.04		100.18
T6'	6.64	T2'+5'	115.01
T5'	6.74	B2'+5'	115.38
B5'	6.75	B6	118.90
B6'	6.78	T6	118.98
T2'	6.95	B1'	131.62
B2'	6.99	T1'	131.72
		B & T	145.00
		3' + 4'	145.04 145.04 145.12 145.20
		B + T 5, 7 + 8a	154.73 155.50 157.44



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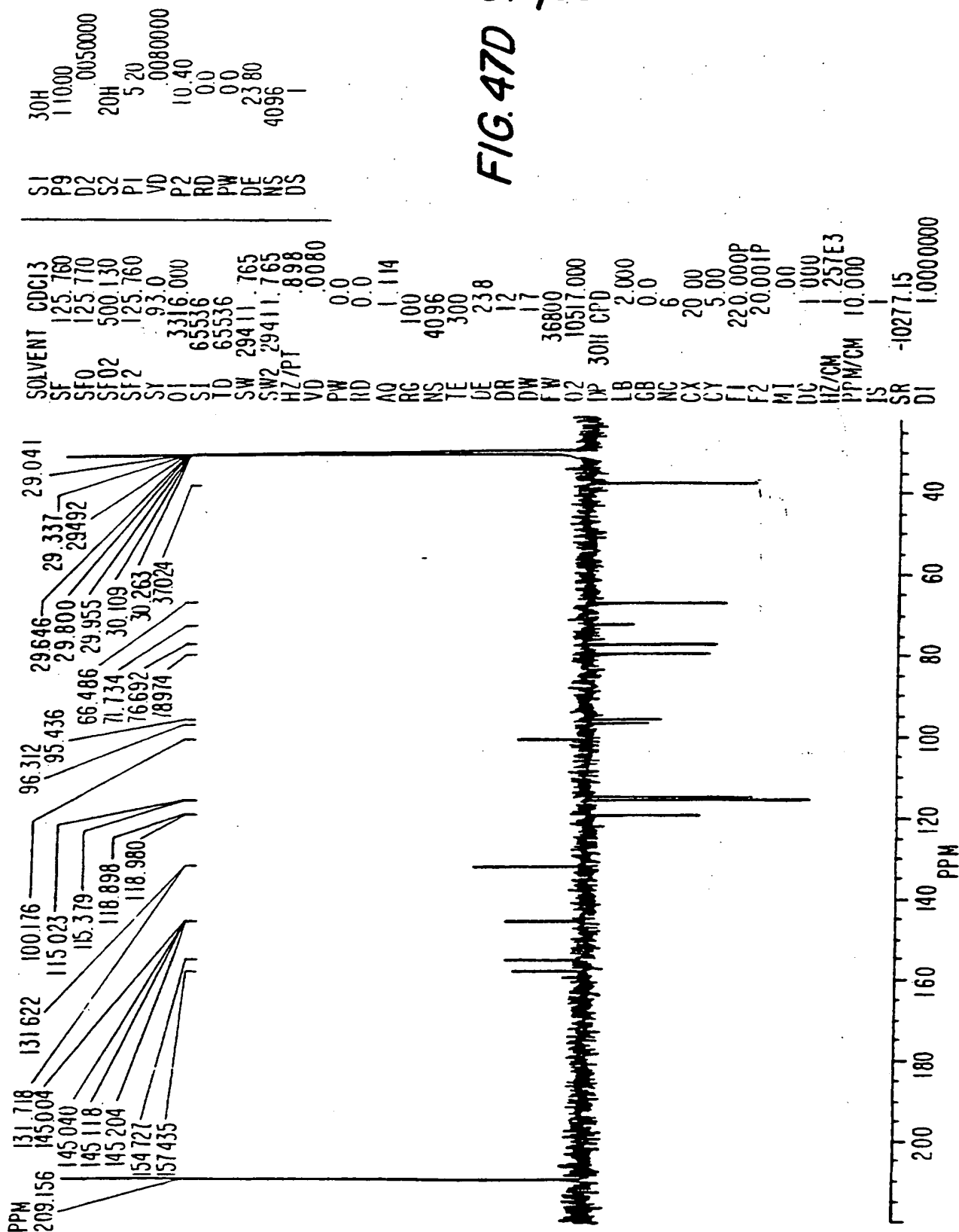
FIG. 47C





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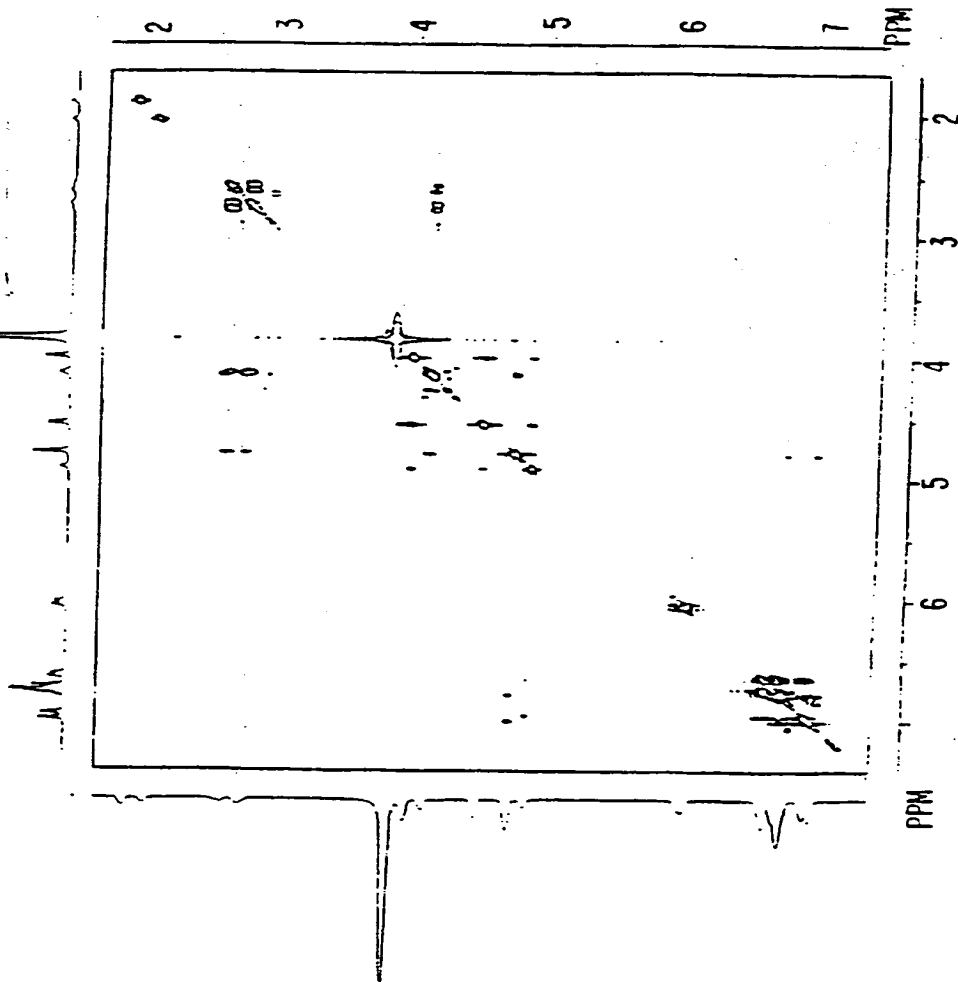
FIG. 47D



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FIG. 47E



F1-PROCESSING PARAMETERS		F2-PROCESSING PARAMETERS	
SI	1024	SI	2048
MC2	OF	SI	360135841
SF	3601357694	WDW	SINE
WDW	SINE	SSB	0
SSB	0	LB	0.000
LB	0.000	GB	0
GB	0	PC	1.40
2D NMR PLOT PARAMETERS		F1-ACQUISITION PARAMETERS	
CX2	12.29	SI	0.0003460
CX1	12.29	SI	3601372
F2H0	7.417	FIDRES	11.289726
F2L0	2671.25	SW	8.025
F2PHI	1.649	WDW	8.025
F2H1	593.94	SI	2048
F1P0	7.467	SI	360135841
F1L0	2688.96	WDW	SINE
F1PHI	1.683	SSB	0
F1H1	606.00	LB	0.000
F2PPMCM	0.46924	GB	0
F2H2CM	168.99025	PC	1.40
F1PPMCM	0.47051		
F1H2CM	169.44925		

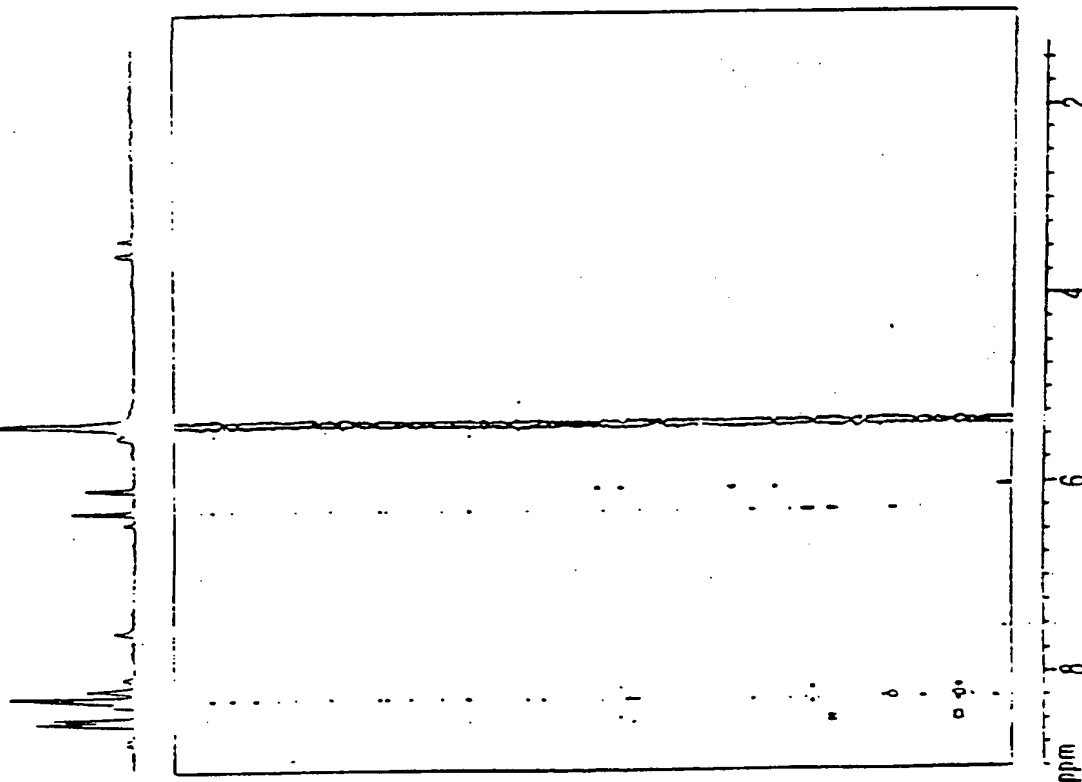
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F1 - PROCESSING PARAMETERS		2D NMR PLOT PARAMETERS	
SI	1024	CX2	13.19
MC	01	CX1	13.19
SF	90.5539705 MHz	F2FLO	9.000
WDW	OSIN	F2LO	3241.22
SSB	0	F2PHI	1.000
LB	0.00	F2H1	359.93
GB	0	F1FLO	180.642
		F1LO	16357.88
		F1PHI	8.626
		F1H1	781.12
		F2PPMCM	0.60644
		F2H2CM	218.39912
		F1PPMCM	13.03894
		F1H2CM	1180.72815

F1 ACQUISITION PARAMETERS		12 PROCESSING PARAMETERS	
inv4	1	SI	1024
dioxone	0	SF	360.1353214 MHz
0.3543240 sec		WDW	OSINE
1.411217 Hz		SSB	2
173.0 usec		LB	0.00
128		GB	0
1H		ppmPC	1.40
NUCLEUS			
PI	1		
CAST2	1		
145.0000000			
1			
1.01000000 sec			
0.034483 sec			
13.5 usec			
90.5625400 MHz			
0.0680000			
0.0000030 sec			
15.0 usec			
247.1 usec			
360.1372440 MHz			
2890.17 Hz			
20.18			
16			
4			
0.000300 sec			

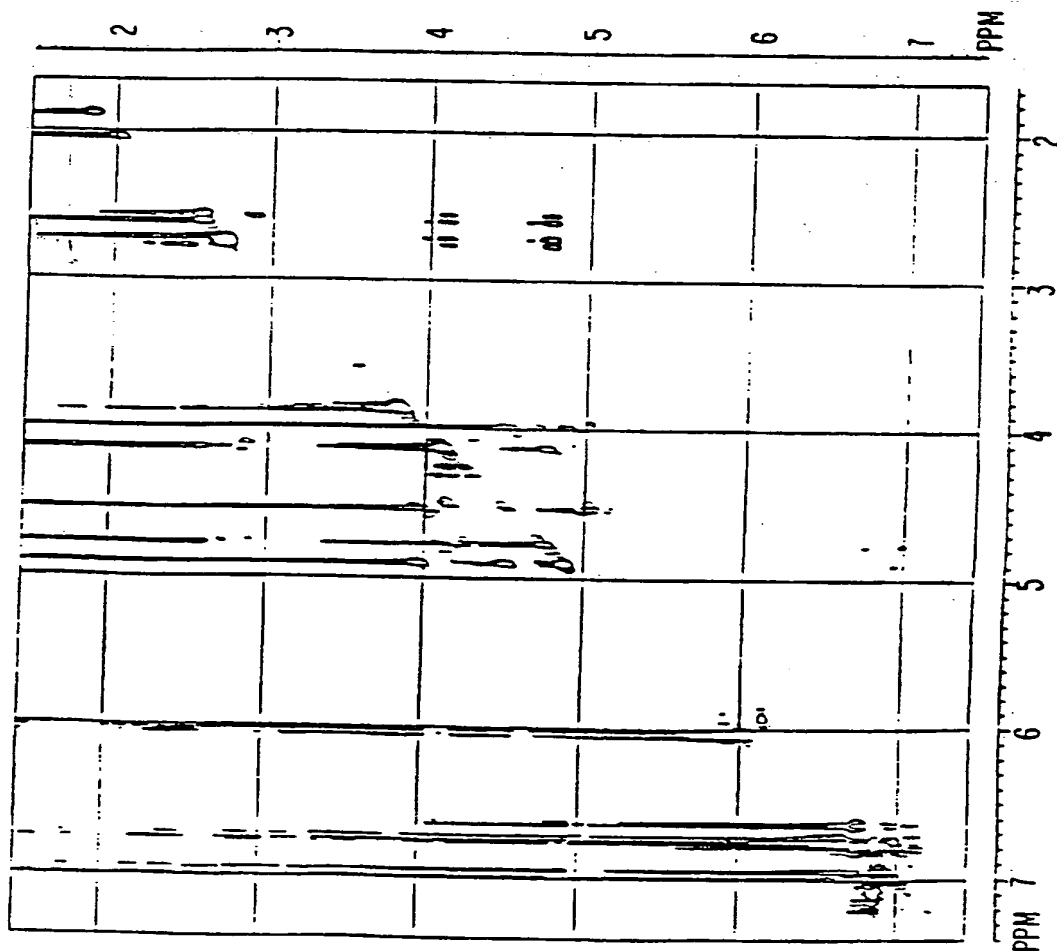
FIG. 47F



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PULPROG	mevprfp	LB	000	Hz
SOLVENT	MeOH	GB	0	
NO	0.3543240 sec	PC	1.40	
FIDRES	1.411217 Hz	F1-PROCESSING PARAMETERS		
DW	173.0 usec	SI	1024	
RG	256	MC2	1PP1	
NUCLEUS		SF	360.1358964 MHz	
P6	520 usec	WDW	SINE	
H11	1	SSB	4	
D11	0.0300000 sec	LB	0.00	Hz
D12	0.000020 sec	GB	0	
HL2	76 dB	2D NMR PLOT PARAMETERS		
P18	10000000.0 usec	CX2	1500	cm
D13	0.0000040 sec	CX1	1500	cm
P1	7.5 usec	F2F10	7.406	ppm
D0	0.0000030 sec	F210	2667.20	Hz
HL3	1.7 dB	F2P11	1.654	ppm
P17	2500.0 usec	F2H1	595.53	Hz
P7	104.0 usec	F1P10	7.444	ppm
L1	56	F110	2681.01	Hz
P5	34.7 usec	F1P11	1.473	ppm
DE	247.1 usec	F1H1	530.31	Hz
SFO1	360.1372552 MHz	F2P1NCM	0.38350	ppm/c
SWH	2890.17	F21ZCM	138.1116	Hz/cm
TD	2048	F1P1NCM	0.39813	ppm/c
HS	8	F1H2CM	143.37968	Hz/cm
DS	4	F1-ACQUISITION PARAMETERS		
INO	0.0001730 sec	NU1	2	
TD	128	SFO1	360.1373	MHz
FIDRES	22.579477 Hz	SW	8.025	ppm
NUC1	128	F2-PROCESSING PARAMETERS		
SI	1024	SI	1024	
SF	360.1358581 MHz	SF	360.1358581 MHz	
WDW	SINE	WDW	SINE	
SSB	4	SSB	4	

FIG. 47G



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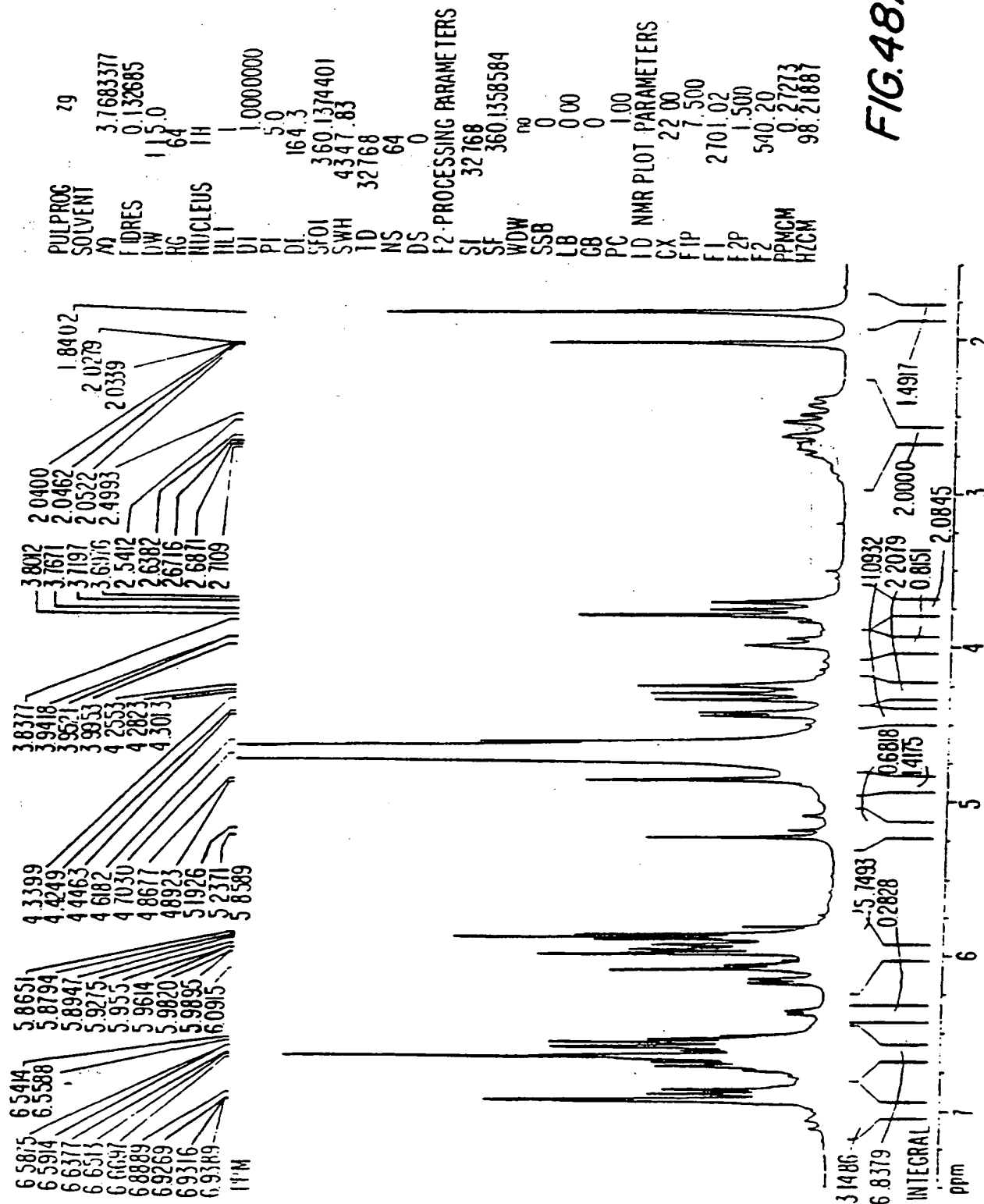
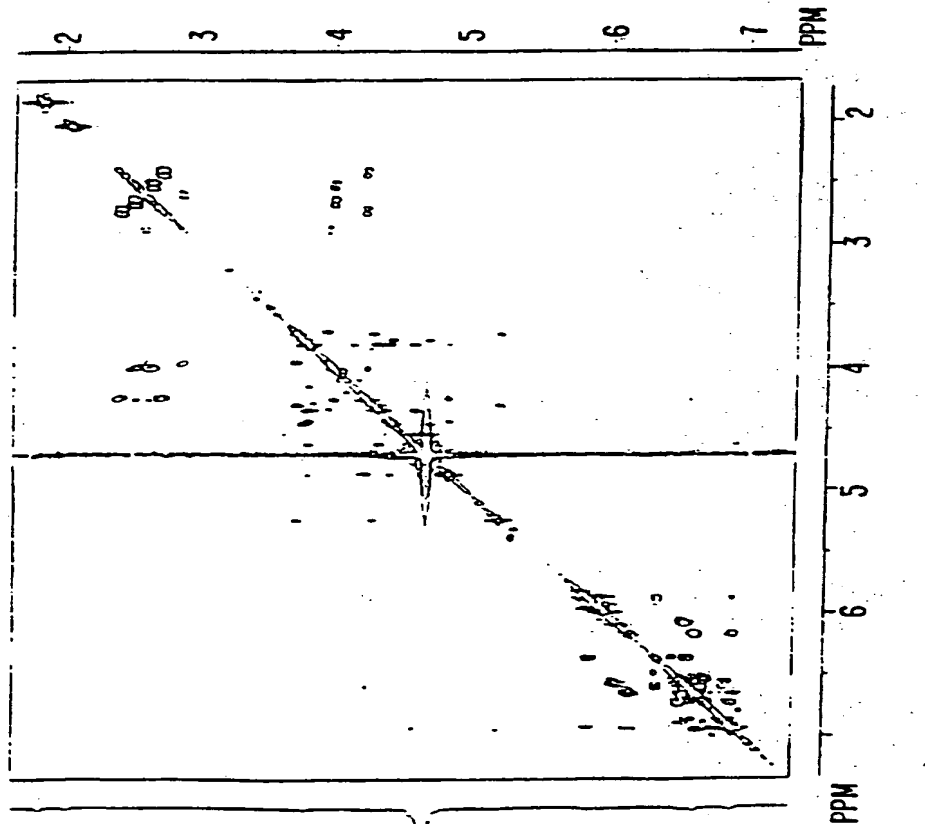


FIG. 48A

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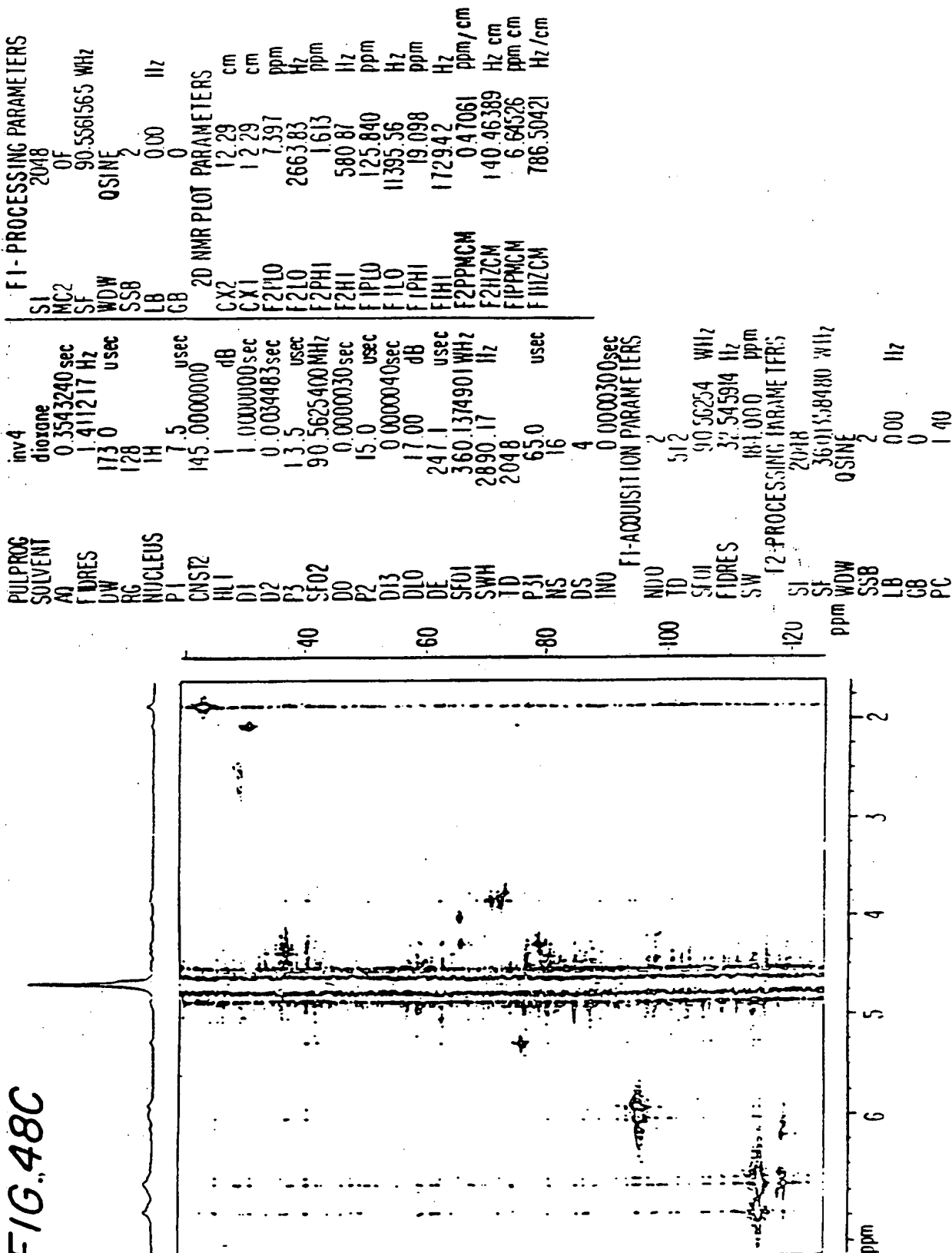
FIG. 48B



F1-PROCESSING PARAMETERS		F1-ACQUISITION PARAMETERS		F2-PROCESSING PARAMETERS	
SI	1024	SI	2048	SI	2048
MC2	OF	MC2	OF	MC2	OF
SF	360 1355256 MHz	SF	360 1355256 MHz	SF	360 1355256 MHz
WDW	SINE	WDW	SINE	WDW	SINE
SSB	0	SSB	0	SSB	0
LB	0.00 Hz	LB	0.00 Hz	LB	0.00 Hz
GB	0	GB	0	GB	0
2D NMR PLOT PARAMETERS		F1-ACQUISITION PARAMETERS		F2-PROCESSING PARAMETERS	
CX2	12.29 cm	SI	2048	SI	2048
CX1	12.29 cm	MC2	OF	MC2	OF
F2P10	7.351 ppm	SF	360 1355256 MHz	SF	360 1355256 MHz
F2P10	2647.53 Hz	WDW	SINE	WDW	SINE
F2PHI	1.677 ppm	SSB	0	SSB	0
F2H1	604.09 Hz	LB	0.00 Hz	LB	0.00 Hz
F1P10	7.360 ppm	GB	0	GB	0
F1P10	2650.41 Hz	PC	1.40	PC	1.40
F1PHI	1.638 ppm				
F1H1	590.06 Hz				
F2P10CM	0.4659 ppm/cm				
F2H1CM	166.23495 Hz/cm				
F1P10CM	0.46541 ppm/cm				
F1H1CM	167.61238 Hz/cm				

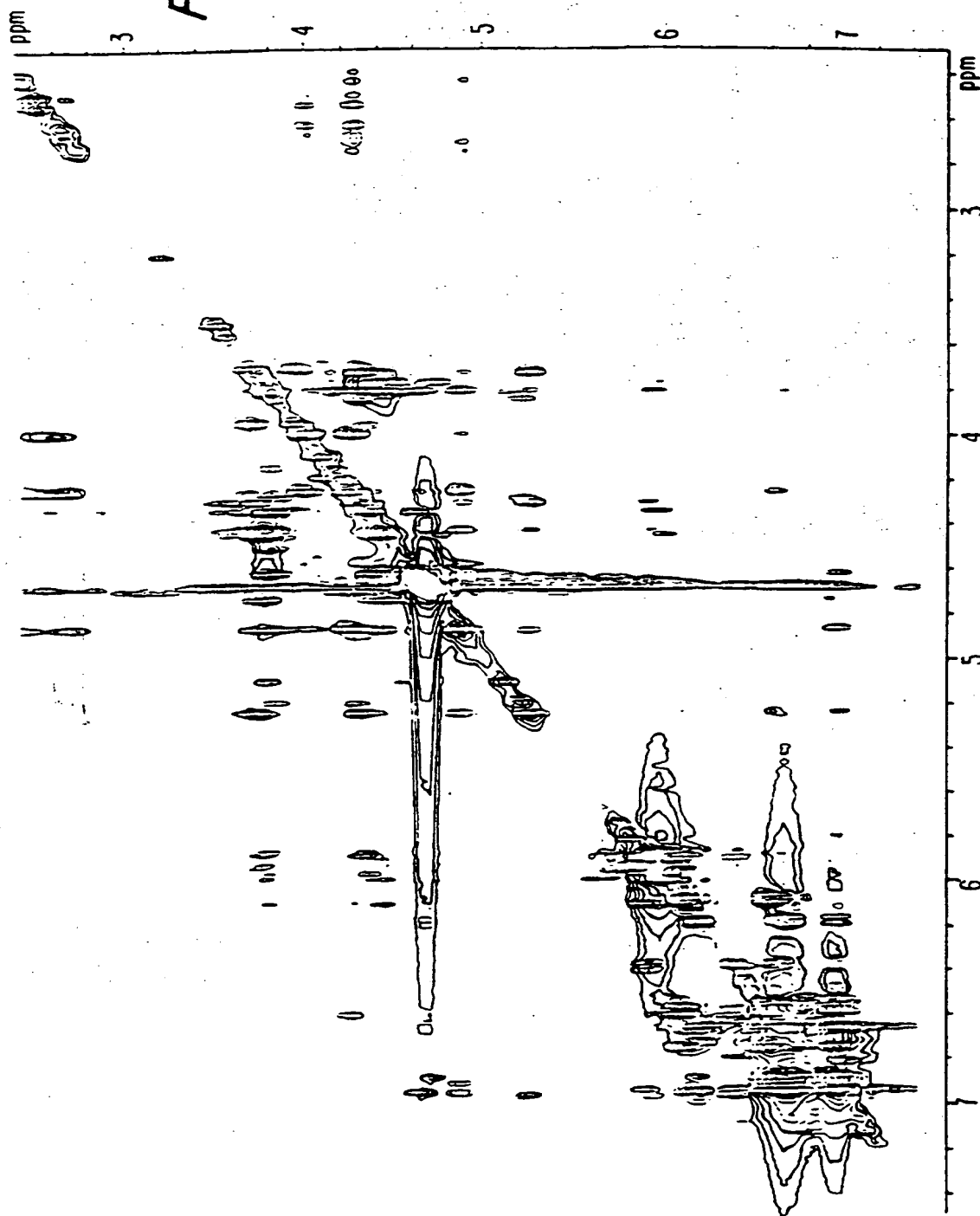
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FIG. 48C



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FIG. 48D





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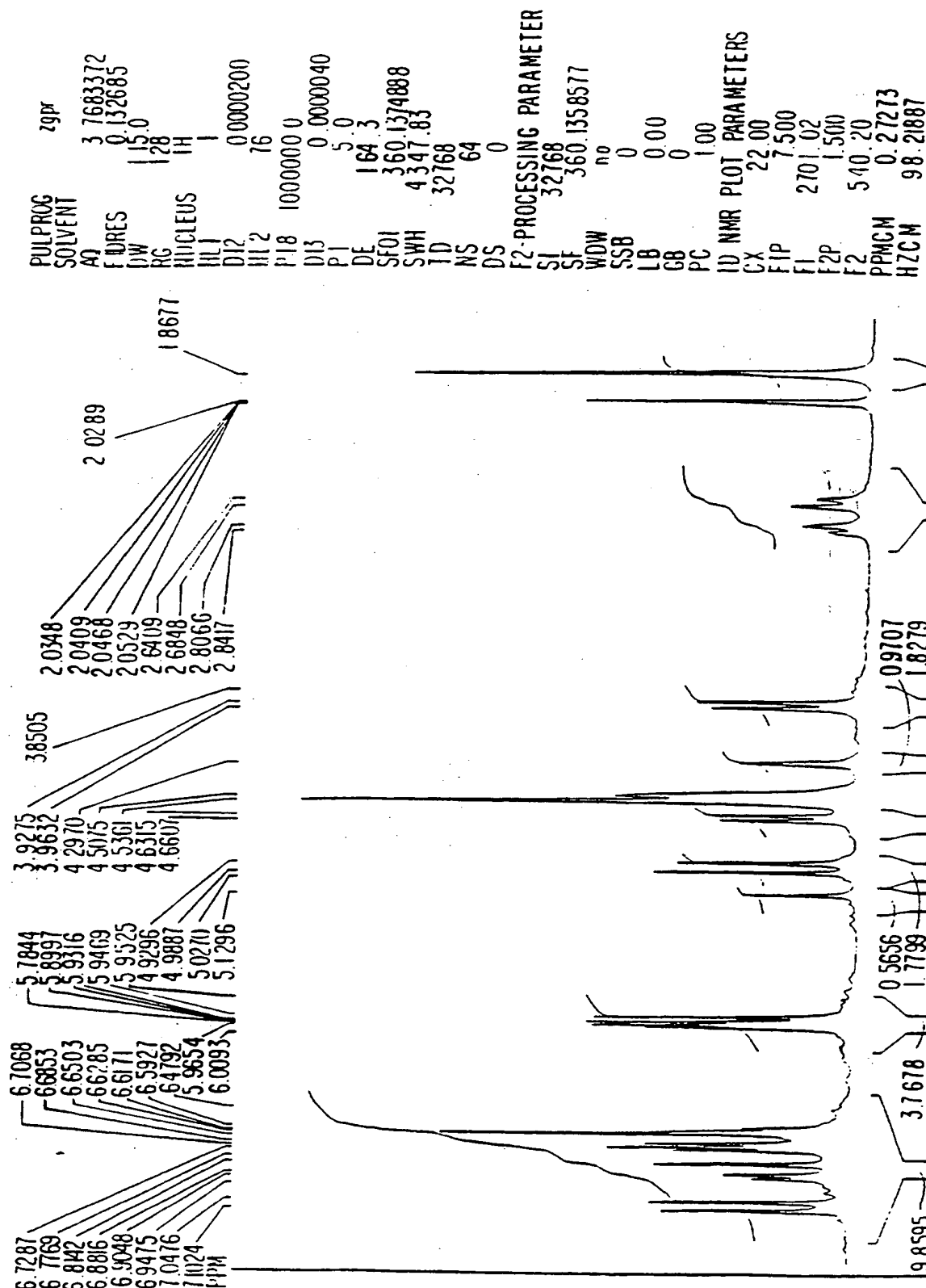


FIG. 49A

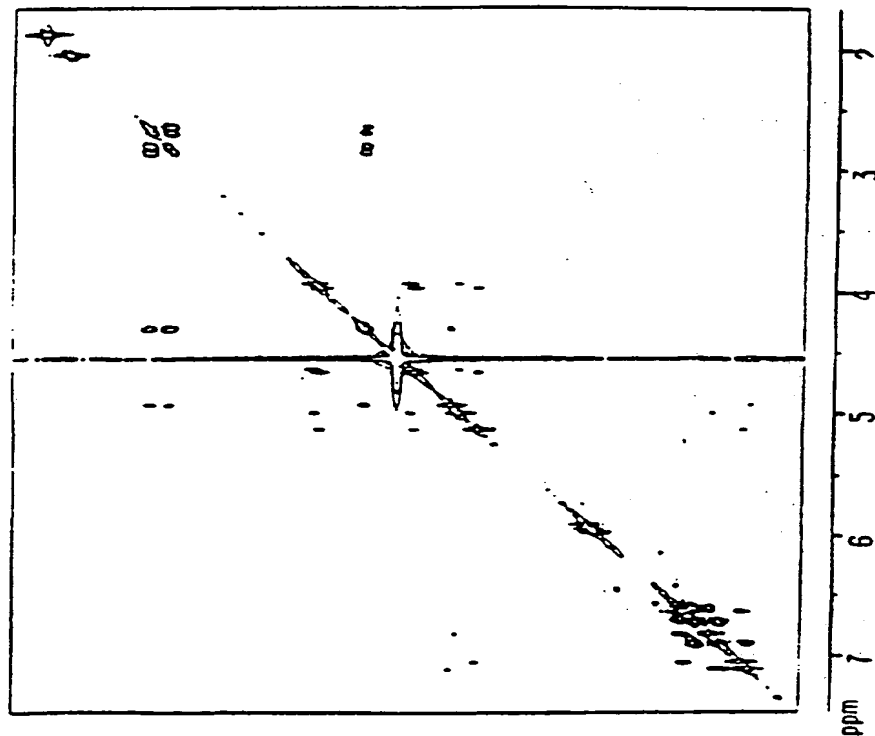
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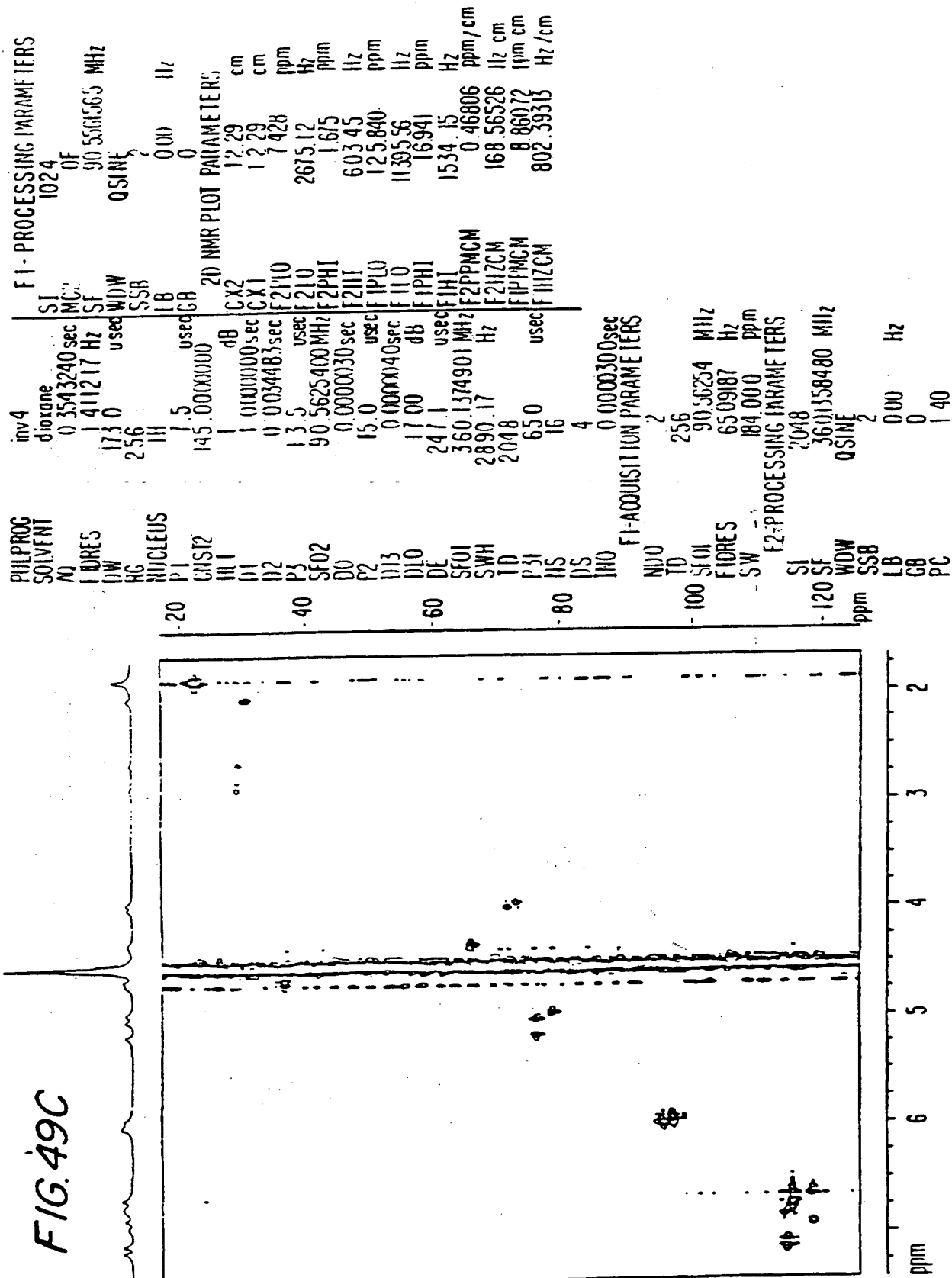
F1-PROCESSING PARAMETERS		F2-PROCESSING PARAMETERS	
SI	1024	SI	2048
MC	OF	MC	OF
SF	360 135256 MHz	SF	360 1358548 MHz
WDW	SINE	WDW	SINE
SSB	0	SSB	0
LB	0.000 Hz	LB	0.000 Hz
GB	0	GB	0
PC	0	PC	1.40
2D NMR PLOT PARAMETERS		F1-ACQUISITION PARAMETERS	
CX2	12.29 cm	SI	256
CX1	12.29 cm	SF	360 1372 MHz
F2F10	7.477 ppm	FIDRES	11.289726 Hz
F2F10	2692.69 Hz	SW	8.075 ppm
F2F10	1.662 ppm	F2-PROCESSING PARAMETERS	
F2PHI	598.44 Hz	SI	2048
F2PHI	7.501 ppm	SF	360 1358548 MHz
F2F10	2700.24 Hz	WDW	SINE
F2F10	1.638 ppm	SSB	0
F2F10	590.06 Hz	LB	0.000 Hz
F2F10	0.47307 ppm/cm	GB	0
F2F10	170.36786 Hz/cm	PC	1.40
F2F10	0.47689 ppm/cm		
F2F10	171.74516 Hz/cm		

F1-PROCESSING PARAMETERS		F2-PROCESSING PARAMETERS	
SI	1024	SI	2048
MC	OF	MC	OF
SF	360 135256 MHz	SF	360 1358548 MHz
WDW	SINE	WDW	SINE
SSB	0	SSB	0
LB	0.000 Hz	LB	0.000 Hz
GB	0	GB	0
PC	0	PC	1.40
2D NMR PLOT PARAMETERS		F1-ACQUISITION PARAMETERS	
CX2	12.29 cm	SI	256
CX1	12.29 cm	SF	360 1372 MHz
F2F10	7.477 ppm	FIDRES	11.289726 Hz
F2F10	2692.69 Hz	SW	8.075 ppm
F2F10	1.662 ppm	F2-PROCESSING PARAMETERS	
F2PHI	598.44 Hz	SI	2048
F2PHI	7.501 ppm	SF	360 1358548 MHz
F2F10	2700.24 Hz	WDW	SINE
F2F10	1.638 ppm	SSB	0
F2F10	590.06 Hz	LB	0.000 Hz
F2F10	0.47307 ppm/cm	GB	0
F2F10	170.36786 Hz/cm	PC	1.40
F2F10	0.47689 ppm/cm		
F2F10	171.74516 Hz/cm		

FIG. 49B



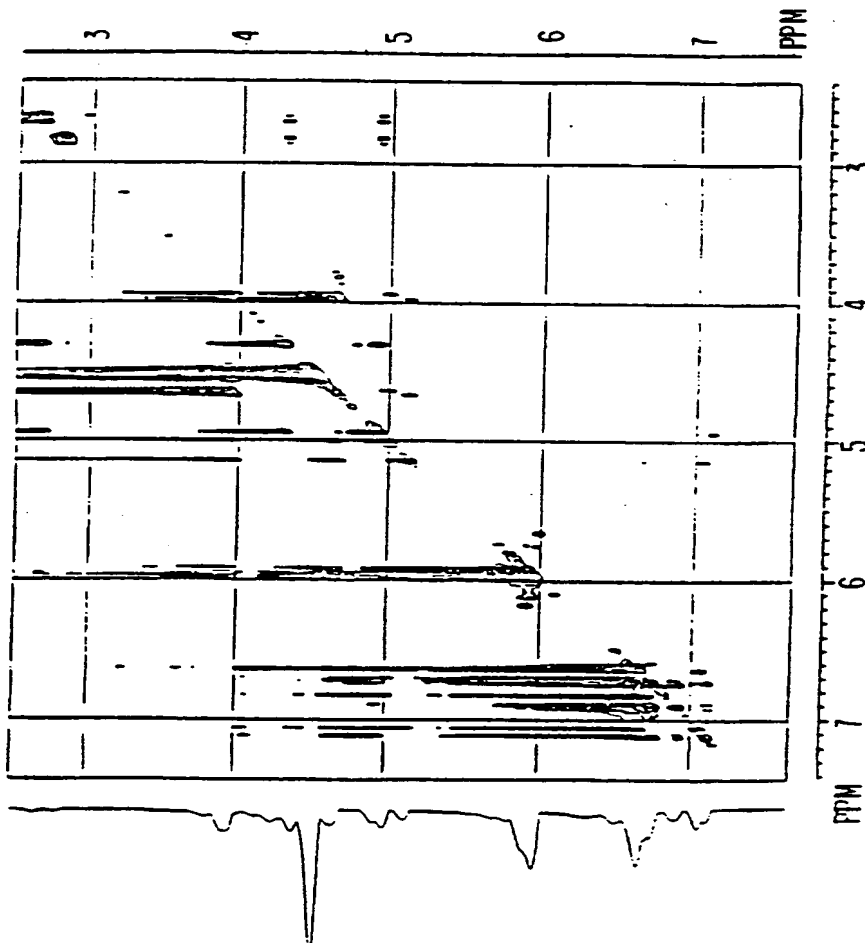
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FIG. 49D



F1-PROCESSING PARAMETERS		F2-PROCESSING PARAMETERS	
PC	140	PC	140
SI	1024	SI	1024
MC2	360.13585 MHz	MC2	360.13585 MHz
SF	SINE	SF	SINE
WDW	4	WDW	4
SSB	000 Hz	SSB	000 Hz
LB	0	LB	0
GB	0	GB	0
2D NMR PLOT PARAMETERS		2D NMR PLOT PARAMETERS	
CX2	12.29 cm	CX2	12.29 cm
CX1	12.29 cm	CX1	12.29 cm
F2I'LO	7.428 ppm	F2I'LO	7.428 ppm
F2ILO	2675.22 Hz	F2ILO	2675.22 Hz
F2PHI	2.397 ppm	F2PHI	2.397 ppm
F2H1	863.21 Hz	F2H1	863.21 Hz
F1ILO	7.652 ppm	F1ILO	7.652 ppm
F1PHI	255.84 Hz	F1PHI	255.84 Hz
F1H1	2.511 ppm	F1H1	2.511 ppm
F2PPMCM	904.32 Hz	F2PPMCM	904.32 Hz
F2IIZCM	0.40939 ppm/cm	F2IIZCM	0.40939 ppm/cm
F1IIZCM	170.36786 Hz/cm	F1IIZCM	170.36786 Hz/cm
F1PPMCM	0.41832 ppm/cm	F1PPMCM	0.41832 ppm/cm
F1IIZCM	150.65236 Hz/cm	F1IIZCM	150.65236 Hz/cm
F1-ACQUISITION PARAMETERS		F2-ACQUISITION PARAMETERS	
INO	0.0001730 sec	INO	0.0001730 sec
ND0	2	ND0	2
TD	128	TD	128
SFO1	360.1375 MHz	SFO1	360.1375 MHz
FIDRES	22.579477 Hz	FIDRES	22.579477 Hz
SW	8.025 ppm	SW	8.025 ppm
SF	360.1358526 MHz	SF	360.1358526 MHz
WDW	SINE	WDW	SINE
SSB	4	SSB	4
LB	000 Hz	LB	000 Hz
GB	0	GB	0
F1-PROCESSING PARAMETERS		F2-PROCESSING PARAMETERS	
PULPROG	mlevprlp	PULPROG	mlevprlp
SOVENT	MeOH	SOVENT	MeOH
AQ	0.3543240 sec	AQ	0.3543240 sec
FIDRES	1.411217 Hz	FIDRES	1.411217 Hz
WDW	173.0 usec	WDW	173.0 usec
HC	128	HC	128
NUCLEUS	1H	NUCLEUS	1H
HL1	1	HL1	1
D11	0.0300000 sec	D11	0.0300000 sec
D12	0.0002000 sec	D12	0.0002000 sec
HL2	76 dB	HL2	76 dB
PI8	1000000.0 uses	PI8	1000000.0 uses
D13	0.0000040 sec	D13	0.0000040 sec
PI1	75 usec	PI1	75 usec
D0	0.0000030 sec	D0	0.0000030 sec
HL3	17 dB	HL3	17 dB
PI7	2500.0 sec	PI7	2500.0 sec
P7	104.0 usec	P7	104.0 usec
LI	56	LI	56
P5	34.7 usec	P5	34.7 usec
DE	247.1 usec	DE	247.1 usec
SFO1	360.1374901 MHz	SFO1	360.1374901 MHz
SWH	2890.17 Hz	SWH	2890.17 Hz
TD	2048	TD	2048
NS	16	NS	16
DS	4	DS	4
INO	0.0001730 sec	INO	0.0001730 sec
ND0	2	ND0	2
TD	128	TD	128
SFO1	360.1375 MHz	SFO1	360.1375 MHz
FIDRES	22.579477 Hz	FIDRES	22.579477 Hz
SW	8.025 ppm	SW	8.025 ppm
SF	360.1358526 MHz	SF	360.1358526 MHz
WDW	SINE	WDW	SINE
SSB	4	SSB	4
LB	000 Hz	LB	000 Hz
GB	0	GB	0

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US96/04497

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : A61K 31/65, 31/70; C07D 321/00; C07H 15/24

US CL : 514/25, 100; 536/18.1; 549/200

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 514/25, 100; 536/18.1; 549/200

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
NONE


Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 3,892,879 (HETZEL et al.) 01 July 1975, column 10, line 38.	1-47

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*A*	document defining the general state of the art which is not considered to be part of particular relevance	*T*	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*E*	earlier document published on or after the international filing date	*X*	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*L*	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Y*	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*O*	document referring to an oral disclosure, use, exhibition or other means	*Z*	document member of the same patent family
*P*	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 16 JULY 1996	Date of mailing of the international search report 27 AUG 1996
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